INTRACRANIAL TUMOURS

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Notes Upon a Series of Two Thousand Verified Cases with Surgical-Mortality Percentages Pertaining Thereto

By

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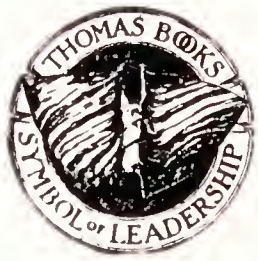

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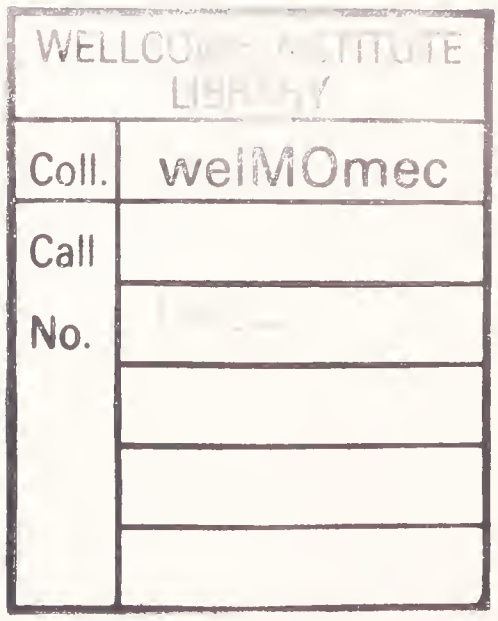

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In Affection and Gratitude

to

My Successive Co-Workers and Assistants
in Neurosurgery

Preface

THE contents of this volume, as the introductory paragraphs will make apparent, formed the basis of a report made September 1, 1931, before the International Neurological Congress in Berne, Switzerland. Assuming from correspondence that what was desired was the brief presentation of the surgical mortality percentages from his clinic, the writer set out to confine himself to this dull task. While the statistical data were being assembled, it became evident that the figures would mean next to nothing unless some account, however meagre, was given of the operations themselves and the various conditions for which they were performed. In putting together the explanatory paragraphs whose purpose was to make the tabulations and percentages appended to the several sections more easily comprehended, the paper has outgrown its original purpose and become monographic in scope.

In the process of preparation it has been necessary to consult innumerable old case histories, to re-examine some of the tumours in the collection, and to reperuse many former publications from the clinic in which fragmentary statistical data had previously been given by those who at one time or another have been connected with the neurosurgical staff. As is so often the case, the expenditure of time and labour needed for this task has been of special value to the writer and his associates, for it has enabled us not only to detect a certain number of diagnostic errors that have crept into our records but has given us a clearer view than we would otherwise have had of the weak spots in our work to which greater attention should in the future be paid.

Whether there will be anything herein of comparable value to others into whose hands the report may fall is impossible to say. The writer, however, is conscious of the fact that had something of the kind been available in his younger days, it would doubtless have enabled him to avoid many pitfalls into which he has stumbled. It would at the same time have given him a set of figures or "score" to compete against and for his own satisfaction to improve upon if possible. The goal of an annual ten per cent case-mortality for all verified tumours, which has long been striven for, has been actually reached and considerably lowered during the past year. Meanwhile, the mortality percentages, both case and operative, for certain special tumours, with whose life history we have become increasingly familiar, has long been below this mark. It may confidently be expected that even our lowest mortality figures for any particular kind of tumour will not long stand; in all likelihood, indeed, still lower percentages have already been attained in other clinics where a fresh start has been made and modern methods employed from the outset.

The laying bare of one's mere mortality percentages, however, is only a start toward what will ultimately be called for: namely, figures relating

to the expectancy of life of those who have survived tumour extirpations. And still more important would be figures for each kind of tumour which would show the percentage of surviving patients whose wage-earning capacity has been restored by operation and for how long a time. But such calculations will have to wait until someone ventures to set a standard for the registration of what in each particular case may well enough prove to be debatable. And the fact that with our shifting population no perfect system has yet been devised whereby all "end results" over long periods of time can be automatically recorded brings added difficulties to such computations. Toward this end, however, the determination of operative mortality percentages may be looked upon as the first step.

As this report represents the work of a single neurological clinic, there is no need for apology in restricting the bibliographical references to some of the publications which have emanated from it. In the several papers cited the larger bibliography of the various subjects discussed up to the date of their publication will be found.

Subject Headings

INTRACRANIAL TUMOURS

Introduction

THE choice of Berne as a suitable place for this gathering gave me particular satisfaction, for in this charming city at the turn of the century I passed at Inselspital and Hallerianum one of the most profitable and enjoyable periods of my early medical training. Professor Kocher, then gathering material for his chapter on *Hirndruck* and allied subjects to appear in Nothnagel's *Specielle Pathologie*, desired information on the effect of increased intracranial pressure upon the venous circulation of the brain. He consequently proposed that I undertake some experiments in that direction and suggested that the work might best be carried out in the department of physiology. No wandering student in search of a place where thirty years ago he might imbibe the scientific spirit and share in the inspiring traditions of a European laboratory could possibly have met with greater good fortune; and it is due to that winter's work under the stimulus not only of Hugo Kronecker but of his then assistant and present successor, Leon Asher, that I largely owe my interest in experimental pathology of the nervous system, out of which grew a determination to devote myself, should opportunity arise, to the surgery of this special field.

At that particular time (1900–1901), the enthusiasm of the preceding decade over the pioneer operations for cerebral tumours had waned and the subject lay under a shadow. The pessimistic views expressed by von Bergmann were shared by most other surgeons; and even Horsley, a born optimist, had failed by his results to convince his neurological colleagues, who turned their tumour cases over to him with reluctance and only as a last resort. During my long sojourn in this city, Professor Kocher undertook but a single operation for what was thought to be a tumour of the brain, the procedure having been abandoned, short of elevating the Wagner bone-flap, because of excessive and uncontrollable bleeding from scalp and cranium. On my return to Baltimore a year later, I found, from the medical and surgical records of the Johns Hopkins Hospital, up to January 1, 1901, that the diagnosis of brain tumour had been made only 32 times in the *circa* 36,000 patients admitted in the decade subsequent to the opening of the Hospital. Of the thirteen patients transferred to the surgical wards, two had been operated upon and these disastrously; in eight instances the tumour had been disclosed at autopsy without preceding operation; and in the other three cases the presumptive diagnosis was uncertified.

From all this, brain tumours did not promise to be an important part of neurological surgery as a whole, and like all beginners I soon found myself engaged in the problems of birth palsy, epilepsy and hydrocephalus,

with which I vainly struggled as others have done before and since.* Of tumours there were few, and in the ensuing twelve years up to 1913, only 194 examples had been verified histologically either at operation or autopsy. Among the cases in this early series there were not more than a dozen enduringly successful tumour extirpations, the larger number of the temporarily favourable operations having been due to the chance exposure and evacuation of gliomatous cysts. Localising diagnoses were inadequate, cranial roentgenology was in its infancy, and such progress as was made in this interval was largely technical and chiefly concerned principles of palliative decompression and the avoidance of the fistulous and fungating wounds which had previously been so disheartening.

My first experience with an intracranial tumour was as follows:

A well nourished but undersized and sexually undeveloped girl 16 years of age was admitted to Dr. Osler's service at the Johns Hopkins Hospital on *December 12, 1901*, with the complaint of headaches and failing vision. She had a peculiar waxy appearance of the skin which suggested nephritis, and though the urine of low specific gravity was considerably increased in amount, no renal elements were ever found. The optic nerves were said to show atrophy with superimposed oedema; and constriction of the visual fields, though not plotted, was apparent on rough tests.

On *February 21*, *March 8* and *March 17, 1902*, under the encouragement of my then neurological colleague, the late H. M. Thomas, three exploratory operations were performed. They served merely to disclose an internal hydrocephalus. The patient became increasingly stuporous, developed quadripedal rigidities, and finally died on *May 1*, of inanition with a terminal pneumonia. There was found at autopsy a tumour of the interpeduncular region which was diagnosed by Dr. Welch as a teratoma arising from an anlage of the pituitary body.[1]

The postmortem disclosure of this wholly unsuspected and apparently inoperable tumour was highly disconcerting and made on me a deep impression. Interest was further aroused by Fröhlich's description in the same year of a pituitary tumour associated with what was called adiposogenital dystrophy rather than the acromegalic changes supposedly produced by a tumour in this situation. This coincidence was what incited my long-time interest in pituitary disorders; and as a contrast to the inadequate and fumbling way in which this girl's case was studied and treated thirty years ago, another story may be told. For on *April 15, 1931*, what proved to be my 2000th intracranial tumour—also a pituitary lesion—was surgically verified.

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* The labour in so far as it indirectly concerned brain tumours was not wholly in vain, for out of it came Dandy's studies of experimental hydrocephalus leading to his notable contribution of ventriculography; also Weed's and Wegefarth's studies of the cerebrospinal fluid circulation leading up to Ayer's cisternal puncture, and to the effect of hypertonic solutions in temporarily reducing states of intracranial tension particularly when due to acute secondary hydrocephalus as shown by Foley, Putnam and Wislocki.

[1] *Cf.* "Sexual infantilism with optic atrophy in cases of tumour affecting the hypophysis cerebri." J. Nerv. & Ment. Dis., 1906, XXXIII, 704–716. [Case I].

The patient (Surgical No. 38467) happened to be a woman with early acromegaly suffering from intense headaches and showing a bitemporal hemianopsia. Under local anaesthesia, a frontal bone-flap was reflected, the chiasmal region was exposed, and the bulging sellar diaphragm was electrically incised. The soft adenoma was then sucked out of its bed; the capsule was shrunken by coagulation; the bone-flap was replaced and accurately closed without drainage. So soon as the drapings were removed at the conclusion of the operation, restoration of vision in both temporal fields was demonstrable and the patient was conscious of relief from her headache. Meanwhile, a bit of the soft adenoma had been examined by supravital methods corroborating the preoperative diagnosis of chromophile adenoma. She made a perfect recovery, was up on the third day, and might safely enough have left the hospital at the end of a week's time.

In 1901, an operation such as this would have been looked upon as nothing short of miraculous, and it is only by contrasting the work of to-day with that of yesterday that progress can be fully appreciated. The chief contributory elements to our advance in this interval have been three: the development of a highly specialized surgical technique, more precise localising diagnoses, and a better understanding of the life history of tumours of different types based on their histogenesis—tumours of corresponding types having been shown to have a predilection for particular regions and a highly similar symptomatology.

Sometimes one, sometimes another of these three factors is in the lead. Technical skill is of little avail if one cannot make a correct diagnosis; Dandy's ventriculography placed localisation at a point where neurological studies scarcely seemed longer to be necessary; in ever increasing number tumours began to be precisely exposed whose nature and behaviour were poorly understood; and to-day there is a tendency to overemphasize the subtleties of histological differentiation and to make this, rather than a successful operation, the matter of chief moment. The very fact that the emphasis thus swings from one to another aspect of the tumour problem indicates that many minds directing skillful hands are now concentrating on the subject; and in another thirty years our present operative procedures will doubtless appear as crude to our successors as do those of thirty years ago to us.

Neurological surgery is a large subject and the surgery of brain tumours is a special field within it. Indeed, the day may well enough come when certain surgeons will find enough to keep themselves fully occupied by attending exclusively to tumours of a single type. Some of those present will recall with what astonishment in 1901 Professor Kocher's report of his second thousand operations for goitre was received, whereas to-day there are clinics in which many more thyroidectomies than this are performed in a single year! He once told me that there could be no greater satisfaction for a surgeon than to concentrate on a single problem and to study it not alone from a strictly operative point of view but from every other possible aspect—physiological, pathological, and chemical. So I can foresee that someone some day will be reporting before a Congress such as this his experiences with a series of two thousand pituitary tumours alone, for there is an immense deal of work that still lies ahead

in this single small though highly intriguing subdivision of intracranial surgery.

Our knowledge of intracranial tumours in general is unfolding like a fan. Even now, a multitude of dissertations could be written on histologically differing tumours as they occur in different situations, for the life history of only a few of them has so far been worked out with any degree of thoroughness. In a study of the bio-behaviour of any tumour it is of primary importance to have a clear idea of its cellular composition, but the microscope does not by any means tell the whole story. Only by the constant histological revision of the tissues in a large collection of tumours, in correlation with the patients' clinical histories over long periods of time, can a thorough working knowledge of each type be established. Without laborious studies of this sort prognosis cannot be determined, and it is on prognosis that the character of the various surgical manoeuvres, which are undergoing progressive improvement, chiefly depend.

In making a report on this series of 2,000 tumours, what presumably will be looked for is some precise information regarding the surgical results attained by the various procedures now employed rather than an account of the procedure themselves, which would interest only a small proportion of the congressists. An attempt will be made at least to approximate expectation in this regard even though the figures will be restricted to the mortality percentages for the several groups of cases.* It is fully realized that precise information in regard to what has happened to the survivors is more important than the mere statistical enumeration of the dead and living, but an attempt precisely to calculate, up to a given date, the longevity percentages for so large and variable a group of patients would lead to interminable by-ways of discussion. Such end-result studies can only be profitably undertaken for tumours of a particular type and situation taken one at a time.

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* Several groups of figures will accompany the notes regarding the various types of tumours: (1) the case and operative mortality percentages for the entire period from July 1901 to July 1931; (2) for purposes of comparison with the above, the case and operative mortality percentages for the 3-year period from July 1, 1928 to July 1, 1931; and (3) in the last section will be found a table with year-to-year figures for the cases, new and old, that have been admitted to hospital for operation or reoperation during each successive twelve-months.

Primary Case Subdivisions

It has long been our custom, as often told,[2,3,4,5,6,7] when the case-records are filed after the patient's discharge from hospital, to subdivide the "brain tumour" cases into three categories—t u m o u r-s u s p e c t s, t u m o u r s h i s t o l o g i c a l l y u n v e r i f i e d, and t u m o u r s h i s t o l o g i c a l l y v e r i f i e d.

1. The Tumour-Suspects.—In this group are included the 1,031 patients who in the past fifteen years* have been referred to the Brigham clinic under the suspicion that they might have tumour, but this possibility has been rendered improbable by neurological study or positively excluded by operation or autopsy. In many respects they represent the most interesting of the three groups and their clinical differentiation from actual tumour may often be impossible when patients first come under observation. For more than one reason, therefore, it is highly important to keep track of these patients, for not a few of them have proven in time actually to have been victims of tumour which supposedly had been excluded. Even when a lesion has been exposed at operation, one may entirely misjudge its character and, for example, mistake an aneurysm or an abscess for a tumour. In illustration:

An adult male gave a typical history of a slowly growing cerebral tumour. Examination showed a six diopter choked disc on the right, a four diopter on the left, an upper left homonymous field defect, and a lower left facial weakness. These signs clearly indicated a lesion of the right temporal lobe. There was no fever or leucocytosis.

An osteoplastic exploration disclosed a firm, subcortical encapsulated temporal tumour of large size which was thought to be a meningioma attached to the floor of the middle fossa. Too large to be safely enucleated intact, the growth was electrically incised, whereupon staphylococcal pus poured from the opening! As quickly as possible, before there was any great soiling of the field, the great sac was emptied by the "sucker," the cavity was partially filled with cotton pledgets dipped in Zenker's fluid, and the incision in the capsule was

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[2] Bailey, P. Concerning the clinical classification of intracranial tumors. Arch. Neurol. & Psychiat., 1921, v, 418–437.

[3] Locke, C. E. A review of a year's series of intracranial tumors. Arch. Surg., 1921, III, 560–581.

[4] Cushing, H. Notes on a series of intracranial tumors and conditions simulating them. Arch. Neurol. & Psychiat., 1923, x, 605–668.

[5] Cairns, H. A study of intracranial surgery [A survey of the work covered in 1926–1927]. Special report No. 125. Medical Research Council, London, 1929.

[6] Van Wagenen, W. P. The incidence of intracranial tumors without "choked disk" in one year's series of cases. Am. J. Med. Sc., 1928, CLXXVI, 346–366.

[7] Cushing, H. Studies in intracranial physiology and surgery. London, Oxford Univ. Press, 1926, 146 pp.

* Previous to this time no attempt was made to keep complete records of these cases and to bring them in line with patients having proven tumours.

sutured. The pseudo-tumour was then electrically extirpated in its totality, the patient making a perfect recovery.

Had this apparent neoplasm been looked upon as irremovable because of its large size and difficult position, and had there been a postoperative fatality without subsequent autopsy, the case might well enough have come permanently to be recorded as "tumour unverified."

A recent study of the 1,031 cases to July 1, 1931, recorded as "tumour suspects," has been made at my request by Dr. Abraham Kaplan. The proven or presumptive diagnoses cover a multitude of disorders, both pathological and symptomatic. The *pathological states* include 157 vascular lesions such as arteriosclerosis, aneurysm,[8] etc.; 89 examples of so-called cisternal arachnoiditis[9]—the pseudo-tumour and "serous meningitis" of former days;[10] 50 examples of encephalitis and its sequels; 38 of cerebral syphilis; 34 of multiple sclerosis; 19 subdural hematomas,[11] and so on. The *symptomatic states* include 125 convulsive and epileptiform (usually Jacksonian) states; 74 neuroses, psychoneuroses and hysterical disorders; 54 cephalalgias; 28 examples of optic neuritis with 27 of optic atrophy of undetermined aetiology; and so on.

Approximately one out of every four—viz., 275 of the 1,031 suspects—have been subjected to operation either to settle the diagnosis or because the conditions seemed urgently to demand it. There were 48 postoperative fatalities, giving a case-mortality of 17.4 per cent and a 15 per cent operative mortality. The conditions for which the operations were performed were too variable to make these figures have any particular significance.

2. Tumours Histologically Unverified.—This group comprising 859 cases to July 1, 1931, tends to grow proportionately smaller than the group of tumour-suspects for two reasons: (1) because many unverified tumours come in course of time to be verified, either by secondary operations or at autopsy; and (2) because we are much more likely nowadays histologically to verify the lesion at the primary operation than we formerly were. The list as it now stands includes: (a) patients whose tumour has actually been exposed but no tissue taken for study because of undue vascularity, inadvisability (e.g., chiasmal gliomas) or some other cause; (b) those with inaccessible tumours clearly shown by ventriculography (e.g., mesencephalic tumours) and subjected in years past to decompression alone; (c) those with clinically unmistakable pontine gliomas or obviously metastatic tumours for which operation has been considered futile; (d) the many patients, particularly in days gone by, with obscurely

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[8] Symonds, C. P. Contributions to the clinical study of intracranial aneurysms. Guy's Hosp. Rep. (Lond.), 1923, LXXIII, 139–158.

[9] Horrax, G. Generalized cisternal arachnoiditis simulating cerebellar tumor: its surgical treatment and end-results. Arch. Surg., 1924, IX, 95–112.

[10] Bailey, P. Contribution to the histopathology of "pseudo-tumor cerebri." Arch. Neurol. & Psychiat., 1920, IV, 401–416.

[11] Putnam, T. J. Chronic subdural hematoma: its pathology, its relation to pachymeningitis hemorrhagica and its surgical treatment. Arch. Surg., 1925, XI, 329–393.

localised lesions who were merely decompressed in order to preserve vision and who subsequently were lost track of or died at home without postmortem study.

When patients in this group of unverified tumours survive for long periods of time with quiescent symptoms, one may well begin to doubt the actual presence of a neoplasm and consider the propriety of transferring the case to the group of "suspects." This is particularly true of patients with a cerebellar symptomatology associated with choked disc on whom negative cerebellar explorations have been made, this decompressive measure having been followed by an early and long continued subsidence of all symptoms. On the other hand, the group includes a goodly number of clinically obvious but symptomatically stationary tumours that have not been subjected to operation, some of which, like the hypophysial-duct tumours for example, may have long survival periods.

The unverified tumours show a negligible operative mortality which is necessarily restricted to those few fatal cases in which no postmortem examination has been held; for this would have served either to exclude tumour altogether and place the case in the suspect-group, or to identify a tumour and place it in the verified group. The fact that over 90 per cent of all fatal cases have come to autopsy indicates that a request for a postmortem examination, whether partial and restricted to the brain or complete, is rarely refused.

In a review of the records of these cases to July 1, 1931, Dr. Kaplan finds that 496 of the 859 cases have been operated upon 557 times with 12 postoperative deaths, giving the negligible 2.4 per cent case-mortality and 2.2 per cent operative mortality.

3. Tumours Histologically Verified.—The cases included in this group, which, to July 1, 1931, slightly exceed 2,000 in number, are naturally the ones from which most information can be acquired. The tumours, listed according to their major subdivisions, are shown in the accompanying table (Table I) all but a few of them having been subjected to histological study and the large majority more or less definitely classified.

For the few exceptions to the standard of tissue verification an apologia should be made. In earlier days, as will more fully be explained later on, a cyst containing xanthochromic fluid was erroneously thought to be indubitable evidence of a glioma, and a few cases continue to be so recorded. Furthermore, in our study of the blood-vessel tumours a certain number of angiomatous anomalies, the naked-eye appearances of which are nigh unmistakable, crept into the verified list; and there prove to be two or three tuberculomas that have been accepted on bacteriological rather than on histological grounds. Fortunately the number of these stowaways compared to the passenger list as a whole is so small that they can be neglected. Should they have been thrown overboard in making the present review, the comparative value and accuracy of our earlier compilations would have been impaired; and most of the cysts will pay for their passage by future verification.

One may gather from all this what an immense labour is involved in keeping precise week-to-week records of such a large series of cases—a task which for the past decade has been assumed by Dr. Louise Eisenhardt. Not only do the successive operations, which one may be called upon to undertake, sometimes necessitate frequent transferences between

TABLE I

VERIFIED TUMOURS TO JULY 1, 1931, WITH THEIR PERCENTAGES OF INCIDENCE

			Number	Per cent
I.	Gliomas (varia)		862	42.6
II.	Pituitary adenomas		360	17.8
	Chromophobe	264		
	Chromophile	73		
	Mixed	23		
III.	Meningiomas		271	13.4
IV.	Acoustic tumours (neurinomas)		176	8.7
V.	Congenital tumours		113	5.6
	Craniopharyngiomas	92		
	Cholesteatomas and dermoids	15		
	Chordomas and teratomas	6		
VI.	Metastatic and invasive tumours		85	4.2
	Carcinomas	56		
	Sarcomas	20		
	Hypernephromas	5		
	Myelomas	4		
VII.	Granulomatous tumours		45	2.2
	Tuberculomas	33		
	Syphilomas	12		
VIII.	Blood-vessel tumours		41	2.0
IX.	Sarcomas (primary)		14	0.7
X.	Papillomas (choroid plexus)		12	0.6
XI.	Miscellaneous		44	2.2
	Unclassified tumours of brain	17		
	Cranial tumours involving brain	21		
	Osteomas	14		
	Osteochondromas	3		
	Angiomas	3		
	Adamantinoma	1		
	Cysts (varia)	6		
	Total		2,023	100.

"suspect," "unverified" and "verified" groups, but shifts within the group of tumours already verified are not uncommonly necessitated as new knowledge regarding pathologically obscure tumours is acquired. And wholly apart from this is the epistolary labour involved in pursuing patients, relatives and doctors for information of end-results.

With necessary brevity each of the eleven major groups of tumours which, in the order of their frequence have been listed in Table I, will be serially taken up for consideration in the following sections.

I. The Gliomas

The gliomas, 862 in number, representing 42.6 per cent of all the tumours in the series, were long ago baptized by Virchow with a histologically accurate, convenient and all-embracing family name. For certain other main tumour-groups [e.g., III and IV] we have ventured to introduce simple designations which are histologically noncommittal. This was regarded as necessary, or at least temporarily expedient, as a step toward discarding the various and sundry names—often based on a misconception of the tumour's cytological nature—which obscured their family identity. In the case of the gliomas, on the contrary, but little effort in the past had been made to subdivide them into their several types—or at least such efforts as had been made had not become popularized—and as a consequence the diagnosis of "glioma" was about as far as most pathologists ventured to go. So it was quite inconsistent with our earlier programme toward simplification that five years ago Dr. Bailey and I should suddenly have inflicted ourselves and others with an overelaborate subdivision of these tumours[12] which, to the comfort and convenience of all concerned, except the surgeons, were already known by a common name.

So long as they remained unclassified, however, the gliomas were looked upon as hopeless lesions for which the surgeon supposedly could do little except temporarily to alleviate by decompressive measures some of the more disturbing symptoms. Indeed, it was found that the postural dislocation of a large glioma of the cerebral hemisphere, brought about by its mere surgical exposure, often led to a rapid increase in cerebral tension from extravasation and oedema with marked accentuation of preëxisting symptoms. There consequently was good reason to dread these operations, and many surgeons even to-day are inclined to leave a glioma once exposed respectfully alone, unless it happens to be associated with large cystic cavities which can be evacuated. But even under these favourable circumstances it has been found that the cysts are prone rapidly to refill and the beneficial effects of emptying them are often but temporary in character.

These cysts were believed to indicate degenerative processes and our first feeble effort to establish a working classification of the gliomas was based solely on this gross characteristic; they accordingly were subdivided into s o l i d g l i o m a s , c y s t i c g l i o m a s , and g l i o m a t o u s c y s t s .* It had long been realized that the gliomatous cysts from the

[12] Bailey, P., and Cushing, H. A classification of the tumours of the glioma group on a histogenetic basis with a correlated study of prognosis. Phila., J. B. Lippincott Co., 1926.

* As already stated, traces of this early crude subdivision continue unfortunately to appear in our list of verified tumours (*cf.* Table II). The majority of these "essentially cystic" gliomas have subsequently proved to be astrocytomatous; some few of the ependymomas and polar spongioblastomas are predominantly cystic

standpoint of longevity were more favourable than the other types and in 1923 Paul Martin[13] made a report upon 95 examples in which this fact was duly emphasized. It however became apparent in the course of his studies that many of the supposedly favourable gliomatous cysts, ascribed to degenerative tendencies on the part of the tumour, had actually been replaced, as time passed, by a solid growth.

Meanwhile, with the improvement of cranial roentgenograms, made possible since 1920 by the Potter-Bucky grille, the tendency of certain gliomas to show spotty shadows of calcification began to be recognized, and a study of them to May 1925 was made by Arthur Van Dessel,[14] who estimated that some 14 per cent of all our verified gliomas could have been detected in this way. What is more, this tendency to form lime deposits was looked upon as an indication of slow growth, and might therefore be useful in distinguishing malignant from benign lesions. At about this same time, moreover, the treatment of brain tumours by radiotherapeutic rather than by surgical measures was widely advocated and apparently favourable results were occasionally observed.[15] However, without more definite knowledge of the cellular composition of a given lesion and of its life history and prognosis when unradiated, the beneficial effects ascribed to radiation were necessarily highly impressionistic.

Wholly dissatisfied with this state of affairs, it was at this juncture that Dr. Bailey was encouraged to undertake the unpromising task of seeing what could be done toward a more definite subdivision of the gliomas in the Brigham collection based on a combined study of their apparent histogenesis and their clinical longevity.[16,17] The custom of leaving a non-cystic glioma pretty much alone when surgically exposed, and the tendency to be satisfied with the evacuation of gliomatous cysts without securing tissue to determine their precise nature, proved disadvantageous to the furtherance of these studies; and as my chief contribution toward them was to provide an ample supply of fresh material for investigation, our surgical procedures tended to become more radical than they previously had been. One highly important outcome of this was the early disclosure that cysts, from which the mural tumour-nodule had been

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and we have had one essentially cystic oligoglioma. But the chief error lay, as we now know, in the probable inclusion of a number of cystic angioblastomas which do not belong in the glioma series. Fortunately the percentage of these histologically undifferentiated "gliomatous cysts" is diminishing from year to year as cases so diagnosed have returned because of symptomatic recurrence. Needless to say we now routinely search for and remove the mural nodule from the cyst wall.

[13] Le traitement chirurgical des gliomes cavitaires de l'encéphale. Arch. Franco-Belges de Chir., 1923, XXVI, 807–847.

[14] L'incidence et le processus de calcification dans les gliomes du cerveau. Arch. Franco-Belges, 1925, XXVIII, 845–874.

[15] Bailey, P. The results of Roentgen therapy on brain tumors. Am. J. Roentgenol., 1925, XIII, 48–53.

[16] Bailey, P. A new principle applied to the staining of the fibrillary neuroglia. J. Med. Research, 1923, XLIV, 73–77.

[17] Bailey and Cushing. Microchemical color reactions as an aid to the identification and classification of brain tumors. Proc. Nat. Acad. Sc., 1925, XI, 82–84.

cleanly extirpated, failed to refill—an indication that most xanthochromic cysts were produced by active transudation from the surface of the tumour rather than by degenerative changes within its substance.

The Unclassified Gliomas.—When in 1926 our glioma monograph was finally published, 160 or nearly 40 per cent of the 412 tumours then in the series were still histologically unclassified. Among them were the gliomas of the pons, interbrain and optic chiasm,[18] but these have recently been differentially studied by Dr. Buckley,[19] so that at the present time only about 20 per cent of the 862 recorded gliomas remain unclassified (*cf.* Table II), and we may expect this percentage to diminish year by year.

TABLE II

VERIFIED GLIOMAS TO JULY 1, 1931

A. *Unclassified*		175
Verified by cystic fluid alone	63	
Excluded because differential study impossible	74	
Atypical and transitional forms	38	
B. *Classified*		687
Astrocytoma	255	
Glioblastoma multiforme	208	
Medulloblastoma	86	
Astroblastoma	35	
Spongioblastoma polare	32	
Oligodendroglioma	27	
Ependymoma	25	
Pinealoma	14	
Ganglioneuroma	3	
Neuroepithelioma	2	
Total		862

Even the tumours "verified by encysted (xanthochromic) fluid alone," of which there are now 63 examples, have proportionately diminished from 11.6 per cent to 7.3 per cent of the whole number, owing partly to actual tissue verification of former "cysts" at secondary operations, but still more to our present endeavour to excise the mural nodule at the primary session, only three examples of undifferentiated gliomatous cysts having been added to the series in the past three years.

In 74 of the remaining 112 undifferentiated gliomas, classification will scarcely be possible either for want of sufficient tissue for differential study, or because of imperfect fixation of the preserved specimen, or the highly degenerated character of the lesion. The remaining 38, though obviously gliomas, are tumours so peculiar in structure they have been set aside for a later attempt at classification when their numbers accumulate.

Fully to appreciate the histopathological as well as the clinical vicissitudes which many of these 38 atypical tumours have gone through, attention may be drawn to the remarkable story, briefly given in our glioma

[18] Martin and Cushing. Primary gliomas of the chiasm and optic nerves in their intracranial portion. Arch. Ophth., 1923, LII, 209–241.

[19] Buckley, R. C. Pontile gliomas. A pathologic study and classification of twenty-five cases. Arch. Path., 1930, IX, 779–819.

monograph (page 129), of the ten-year-old child with a highly calcareous 420-gram tumour of the right hemisphere (Fig. 1). This tumour during its recorded three years of life had been the cause of as many clinical diagnoses as, after death, it received pathological ones. It received a contemporary local diagnosis (1907) of angiolithic glio-sarcoma and a fragment sent to Dr. F. B. Mallory for his opinion was merely called "glioma." When restudied in 1926 it was classified with two others as a neuroblastoma because of the numerous unipolar neuroblasts shown by Cajal's silver method. Finally, four years later, because of Dr. Bailey's subsequent misgiving over the propriety of including "neuroblastoma" in his classification, two of

FIG. 1. A nodular and calcareous 420-gram glioma after removal ($\frac{1}{2}$ nat. size).

the three examples were reclassified as medulloblastomas and this particular tumour was relegated to the group of atypical or unclassifiable gliomas.

Another example of a tumour of undetermined nature may be recorded for the first time as follows:

A young man of 27 years (Surgical No. 33332) entered the hospital *February 20, 1929.* In *1923* he began having Jacksonian attacks in his left arm with ensuing palsy which progressed to a left hemiplegia. In *September 1926*, at the Mayo Clinic an exploration with decompression was made without disclosing the tumour. Two years later, *November 1928*, because of increasing tension, a local surgeon reëlevated the flap, tapped a large (250 cc.) xanthochromic cyst and replaced scalp without the bone. The cyst rapidly refilled, necessitating a *circa* monthly puncture for its evacuation.

On admission there was a large bulging tense protrusion over the parieto-central region. The bedridden patient showed a left sensori-motor hemiplegia with homonymous hemianopsia. The cyst was tapped, 120 cc. of syrupy, quickly clotting fluid being removed and replaced by air. The cystograms showed a huge, deep, multilobulated cavity 15 cm. in length extending from occipital to frontal region. There were calcified areas adjacent to it.

On *March 1, 1929,* the scalp at the site of the old flap was reflected and not until a congeries of cysts had been removed was a solid tumour disclosed lying well forward in the depth of the great hole. The chief mass of the growth was removed, the ventricle having been widely opened in the process and the cho-

FIG. 2. Supravital preparation of tumour (×850) showing radially arranged minute peg-shaped cells pointing toward faintly shown blood-vessels. Diagnosis: ependymoma(?).

roid plexus excised. It was found necessary to leave behind a small fragment of the tumour which lay in the vicinity of the foramen of Munro, every effort to dislodge it having led to bleeding difficult to control.

The appearance of the cells on supravital examination suggested ependymal spongioblasts (Fig. 2); and their architectural arrangement in relation to the blood-vessels was that seen in ependymomas though the cells were minute and no blepharoplasten were demonstrable. The fixed-tissue sections added nothing new, other than the presence of abundant fibrillae, and the growth was reported to be "a glioma presumably of slow growth and favourable prognosis."

Recovery from this operation was most satisfactory and on his discharge, *March 16,* the patient walked from the hospital. He did well for six months

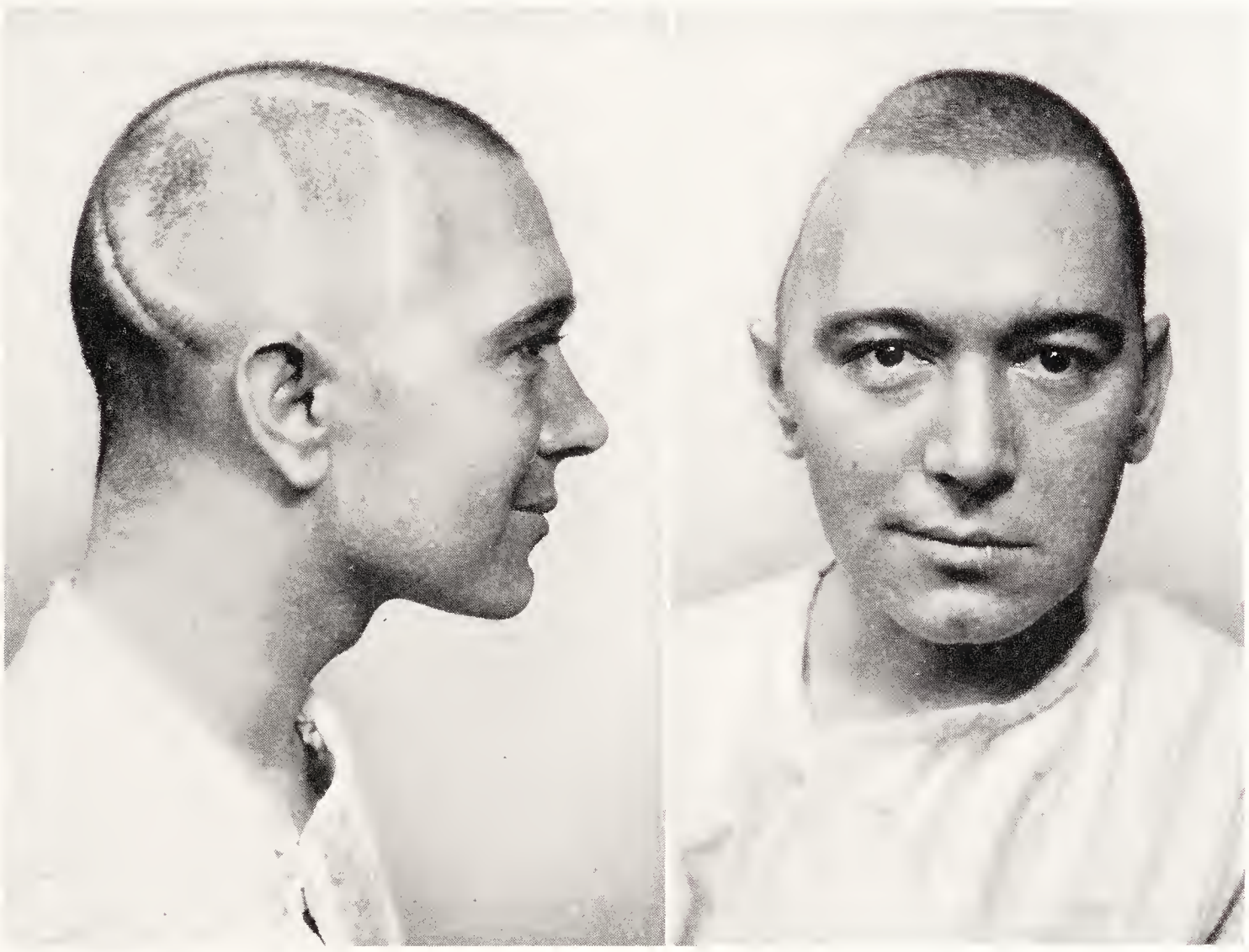
when there were signs of recurrence and repeated punctures of a reformed cyst were again necessary.

He was brought back to us *February 17, 1930,* in about the same condition as the year before. On *March 4,* at a fourth operation, a huge 282-gram recur-

FIG. 3. Showing 282-gram portion of tumour after removal; solid part above, cystic part below.

rent, partly cystic tumour (Fig. 3) was found and the attempt wholly to extirpate it was abandoned short of completion, after a dual transfusion. A small fragment of the growth, in the same situation as before was left undetached.

On *March 12,* at a fifth operation, the wound was reopened and the effort made to dislodge the residual tumour-fragment but this again had to be abandoned owing to loss of blood once more necessitating transfusion. Before closure the residual fragment was coagulated and six radon seeds were implanted in it. Recovery was rapid and on *March 28* he was discharged (Figs. 4, 5) once more able to walk with but slight assistance.



FIGS. 4, 5. Patient on second discharge, to show situation of collapsed flap. Residual hemiparesis of face apparent.

The recurrent tumour had the same histological composition as the original specimen, though occasional mitoses were observed. It was again looked upon as a probable ependymoblastoma, but Dr. Bailey, who subsequently examined the specimens for us, regarded the growth as unclassifiable.

The patient did well for a year when symptoms again returned and in my temporary absence from the clinic Dr. Ernest Sachs was kind enough to take the case in hand. On *March 17, 1931,* in St. Louis he again reflected the old flap for the sixth time and removed a 140-gram recurrent and partly cystic tumour with the same immediate relief from symptoms that had been observed after the preceding operations.

Statistics.—Of these 175 histologically unclassified gliomas, many of them being tumours of huge size, 158 have been operated upon 237 times

with 33 fatalities, giving a 20.9 per cent case-mortality and a 13.9 per cent operative mortality.

The Differentially Classified Gliomas.—As Table II will show, 687 out of the 862 gliomas have now, with reasonable precision, been subdivided on a histogenetic basis into their several types. To be sure, Globus, Bailey, Roussy with his co-workers, Greenfield, Penfield and others, who have industriously put themselves to the laborious task of differentiating these lesions, have not been wholly in accord in their terminology. Time, however, will doubtless bring order, agreement and simplification out of the existing confusion. What is important for the surgeon is to know the kind of glioma he has brought to view, whatsoever its "alias." A medulloblastoma by any other name is just as unfavourable. And since the ultimate purpose of all this is—or should be—to bring benefit to those who are tumour-victims by improved methods of treatment, it is important not to lose sight of the main problem in restricting one's view of it to the microscopic field.

Histological methods.—Since the dawn of operations for cerebral tumour what has usually happened is as follows: A neurologist makes a localising diagnosis of an accessible growth; a surgeon exposes it and if fortunate may remove it, having little idea of its nature; a pathologist, after a considerable interval, during which the precise appearance of the lesion in the fresh has been long forgotten, reports that it is a glioma. This made no great difference in days when another glioma was not likely to be encountered for months; but now that it may be an almost daily occurrence the surgeon needs information that is more specific and more prompt.

For this purpose the supravital method developed by Dr. Eisenhardt[20] of examining a bit of fresh tissue by making a smear of the living cells cannot be too highly recommended, and it will certainly come to supplement, even if it cannot be expected wholly to supersede, the older methods of studying the gliomas by sectioning and staining them after fixation. The general architecture of the lesion, which can only be determined on fixed sections, may be an important element in the diagnosis, but this is supplementary to the primary determination of the predominating cellular element which is the basis of an histogenetic classification. By the supravital method the cell with its intact processes is spread flat, and a favourable preparation has all the appearance of a pure culture of cells [*cf.* Fig. 38]. On the other hand, one usually must scrutinize field after field of sectioned and stained tissues, whether frozen or hardened by a fixative, to get sufficiently good isolated examples of cells for photomicrographic purposes; and even then the cell bodies are so puckered and shrunken by the preservative they bear only the faintest resemblance to their appearance when alive.

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[20] Eisenhardt, L. Diagnosis of intracranial tumors by supravital technique. Am. J. Path., 1930, VI, 541–552.

Apart from all this, the supravital method serves, in the large majority of cases, to give the surgeon immediate information of the precise nature of the lesion before him, and he soon comes to associate the coarser structure of the glioma he has exposed with its probable histological nature. To know from its gross appearance whether a glioblastoma, an astrocytoma or an oligo-glioma has been laid bare is of the highest importance from the standpoint of prognosis on which, as previously stated, the appropriate surgical procedure largely depends. Hence, however interesting as a purely scientific quest the subdivision of the gliomas proves to be, what the patient and the surgeon have gained from it is the practical knowledge that n o t a l l g l i o m a s a r e h i g h l y m a l i g n a n t

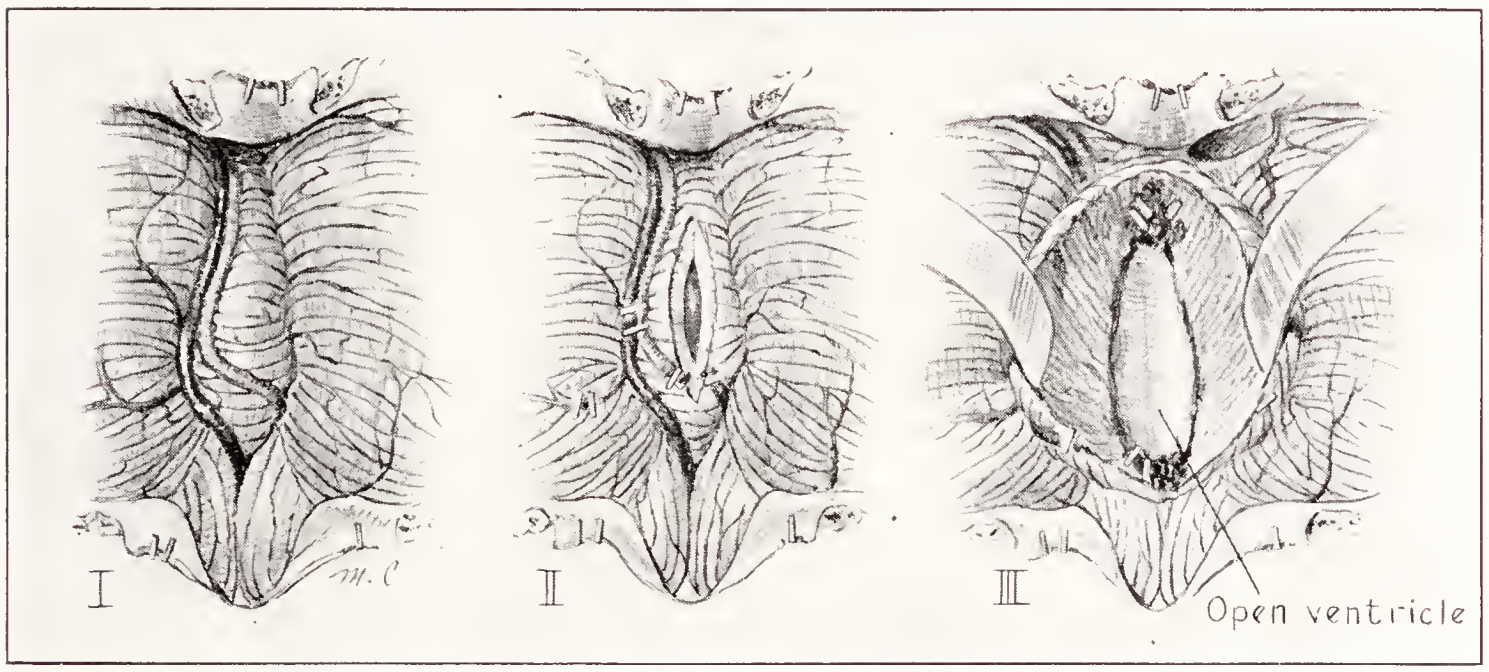

FIG. 6. Drawings from sketches at primary operation showing: I. bulging vermis; II. median incision; III. open fourth ventricle with fragments of tumour left *in situ* at its anterior and posterior poles (reduced $\frac{1}{3}$).

b u t m a n y a r e s l o w g r o w i n g a n d f a v o u r a b l e f o r s u r g i c a l r e m o v a l, if ways can be found to accomplish this end without undue risk to life and without permanent damage to the environmental structures whose function is essential to a life worth living.

The 687 classified gliomas are herein divided into ten groups which are listed in Table II in the order of their frequency. Only a few of them have as yet been comprehensively dealt with from the standpoint of their bio-behaviour and operability. The life history of the larger number, with a study of their seats of predilection, their peculiar clinical syndromes, their course unaffected by operation, the effect of operations of various kinds as well as of radiotherapy in checking their progress, still needs to be worked out. Consequently at the present time it must suffice briefly to give some impressions of the proper methods of dealing with those types whose life history is still obscure.

THE ASTROCYTOMAS

These tumours, the *glioma durum* of earlier writers, 255 in number, represent nearly 40 per cent of all the classified gliomas, and since they prove to be relatively benign lesions this single disclosure justifies all the labour and time expended on the microscopic study of the series as a whole. The unexpectedly long survival period of certain patients known to have had an incompletely removed glioma, the apparently beneficial effect of radiation for gliomas in general, together with other sources of past confusion, have been explained away by establishing the chronicity of these particular tumours.

1. *The Cerebellar Astrocytomas.*—These, 91 all told, are the only ones so far to have had their life history comprehensively studied; and this promptly reflects itself in a great improvement in the operative results. The tumours are all composed of fibrillary and protoplasmic elements in varying proportions; they are essentially tumours of childhood, the average age being thirteen years; they are apt to be predominantly cystic; they do not tend to recur, provided the mural tumefaction which gives origin to the cyst is identified and removed.

The surgical method of dealing with them has been fully illustrated in my Bevan Lecture[21] in which the cases up to August 18, 1930, were fully analyzed. At that time, owing chiefly to recurrences due to lack of understanding of the life history of the lesion no less than to imperfect technique, 113 operations had been performed on 76 patients with 15 fatalities, giving a case-mortality of 19.7 per cent and an operative mortality of 13.3 per cent.

Statistics.—These figures can now be somewhat improved by the addition up to July 1, 1931, without further fatalities, of fifteen new cases and four additional reoperations for recurrences in early cases incompletely treated at the primary operation. This gives for the whole series 16.6 per cent case-mortality and 11.2 per cent operative mortality. But a far better indication of what can be done with the lesion, whose behaviour is now so well understood, is shown by the figures for the last consecutive 29 new cases (one-third of the total number), that have first come under observation in the three-year period from July 1928 to July 1931. In all of these 29 cases, with one or two exceptions, the tumour has been wholly removed from the cyst wall so that there is small likelihood of recurrence, with only one death after 34 operations. This gives a present-day case-mortality for the cerebellar astrocytomas of 3.4 per cent and a 2.9 per cent operative mortality.

It is evident from these last figures that five of the 29 cases even in this short three-year interval were reoperated upon because of incomplete procedures at the first session. For this there may have been good reason as in the following example:

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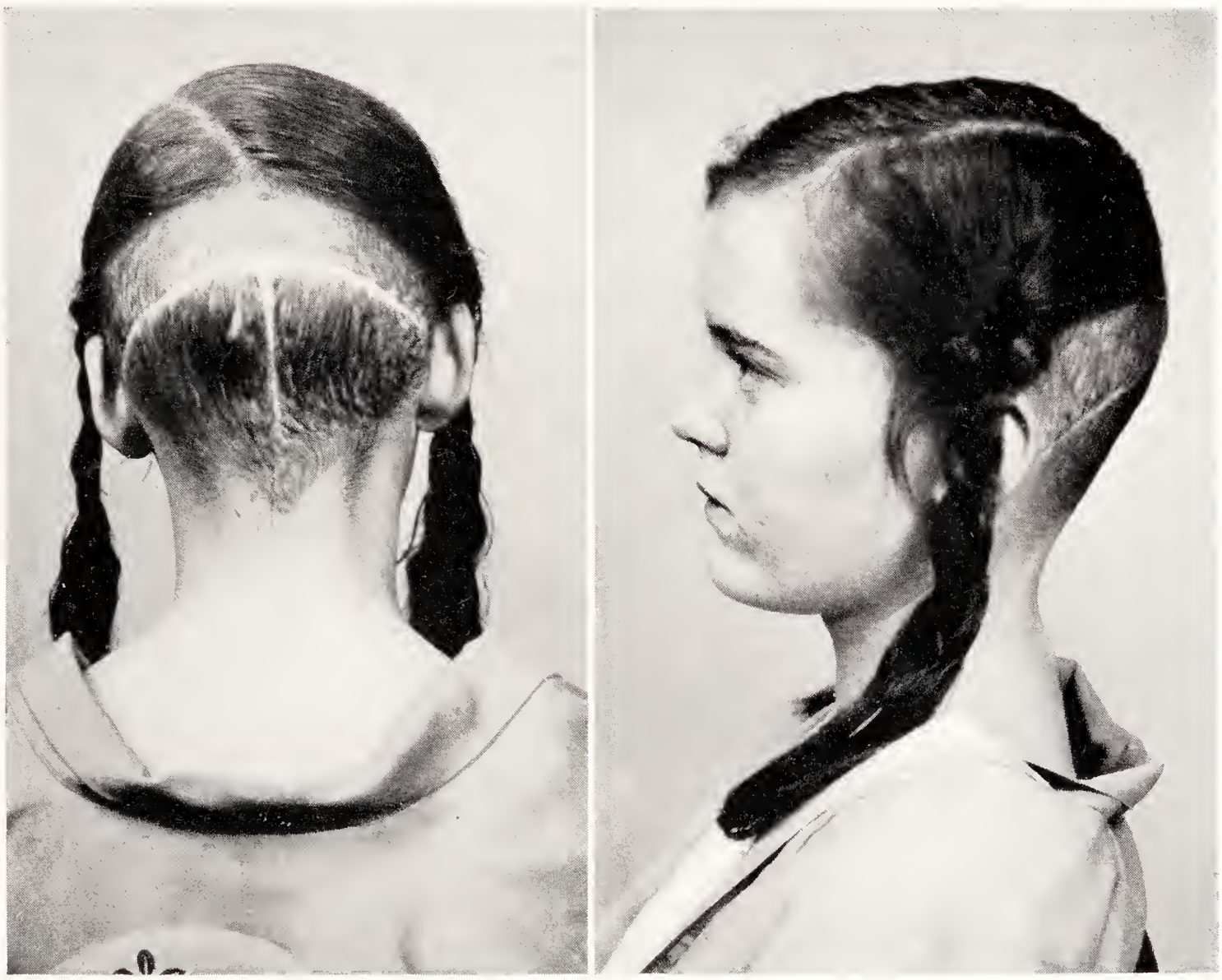
[21] Experiences with the cerebellar astrocytomas: a critical review of 76 cases. Surg., Gynec. & Obst., 1931, LII, 129–204.

The patient, a girl of 14 (Surgical No. 33768), was admitted *April 18, 1929*, with a typical two-year history of progressive suboccipital headaches, morning vomiting, instability, and recent diplopia. She had choked discs of 5 diopters, fortunately with but slight impairment in vision.

The diagnosis of "probable median cerebellar astrocytoma" was made, and on *April 22*, under local anaesthesia, in course of the usual suboccipital exploration with ventricular puncture a tense cerebellum was exposed with marked herniation of the tonsils (*cf.* Fig. 6). No surface tumour was visible but a vertical incision through the widened vermis came down upon a large, partly cystic growth which proved to be unusually vascular and so friable the attempt to



FIGS. 7, 8. Showing patient on discharge (May 14, 1929) after first operation.

enucleate it intact was abandoned. Suction methods were used and finally its deeper portion was lifted out together with the roof of the IVth ventricle leaving the ventricular floor freely exposed. It was quite obvious that there were residual tags of tumour, one in the region of the calamus and another high up under the tentorium in the neighbourhood of the iter, but it was felt that nothing more could be safely done at this session. The girl made an excellent recovery from this operation with early subsidence of the choked discs and she was discharged on *May 14*, practically symptom free (Figs. 7, 8).

The tumour in the fresh and on fixed section was a typical fibrillary astrocytoma.

She remained in perfect health for nearly two years when a return of headaches, occasional vomiting and some instability led to her readmission. There

was unmistakable symptomatic evidence of recurrence though at this time with no choking of the discs.

On *March 17, 1931*, again under local anaesthesia, the original flaps were once more reflected and a large recurrent partly cystic tumour, which fortunately had not become adherent to the floor of the ventricle, was again exposed. It was dislodged intact by prolonged, painstaking electro-surgical dissection (Fig. 9). The patient behaved extraordinarily well during this long five-hour operation in spite of occasional attacks of vomiting and subjective dizziness during the manipulations of the growth.

The tumour (Fig. 10) proved to be of precisely the same histological type as before. She again made an excellent recovery and was discharged (Figs. 11, 12) on *April 8, 1931*, practically symptom-free, with normal vision (cor-

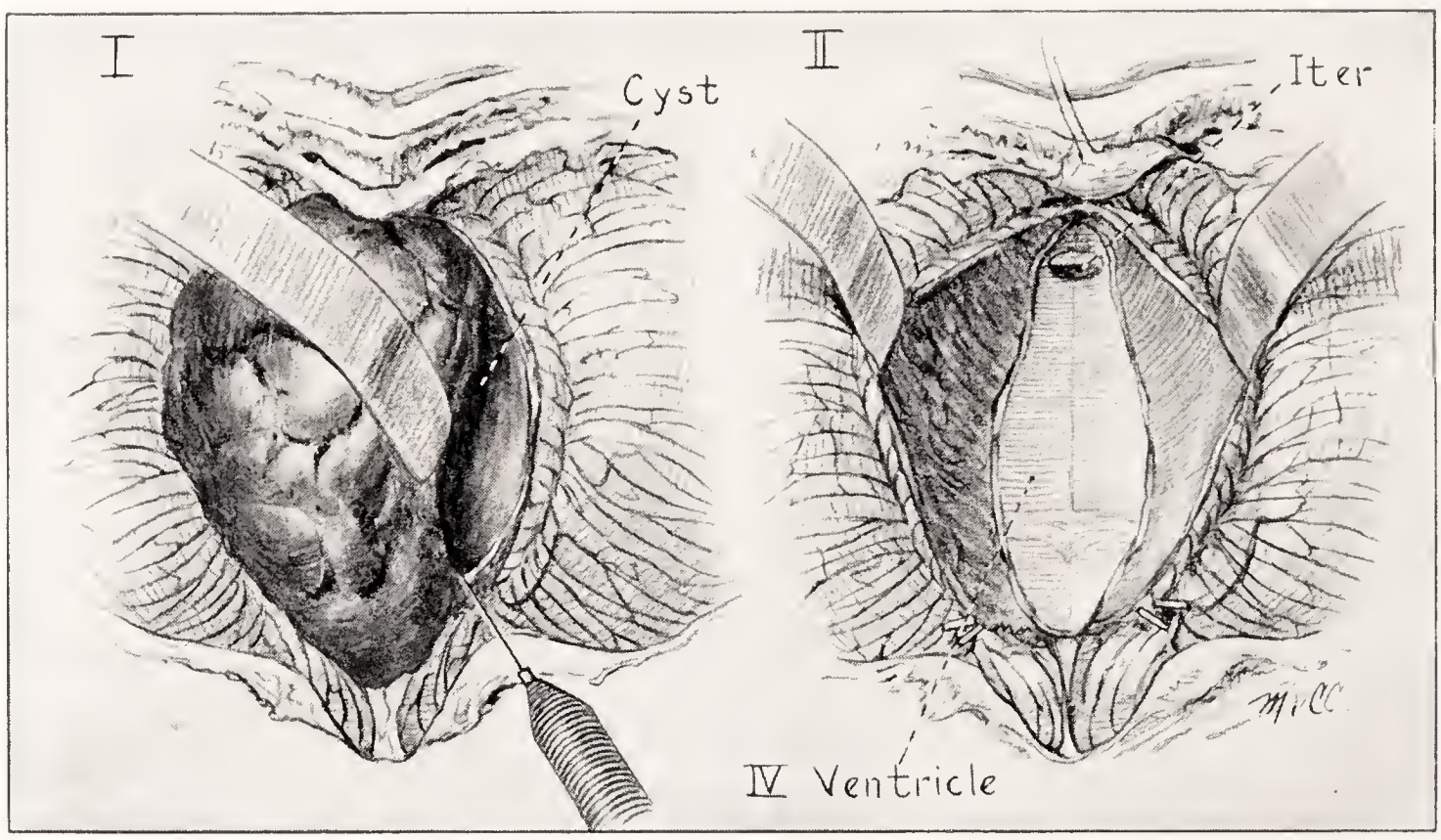


FIG. 9. Sketches indicating steps of secondary operation for recurrence of fibrillary astrocytoma after two years.

rected) and only slight temporary increase in her instability. At the present time (*July 1*) she is again leading a life of normal activity and to judge from past experience may well be regarded as cured.

2. *The Cerebral Astrocytomas.*—These, 164 in all, outnumber those found in the cerebellum by two to one. They moreover are tumours of adult life; they are much less often cystic in character; and to judge from their tendency to early recurrence, they appear to have a much less favourable prognosis than the tumours of similar cytology described above. They unquestionably need further study in connection with the clinical records before their relation to the more carefully worked out gliomas of the cerebellum can be established. It is almost certain that a number of tumours not predominantly astrocytomatous are incorporated in the list which includes many cerebral tumours classified as long ago as 1924 and not since restudied.

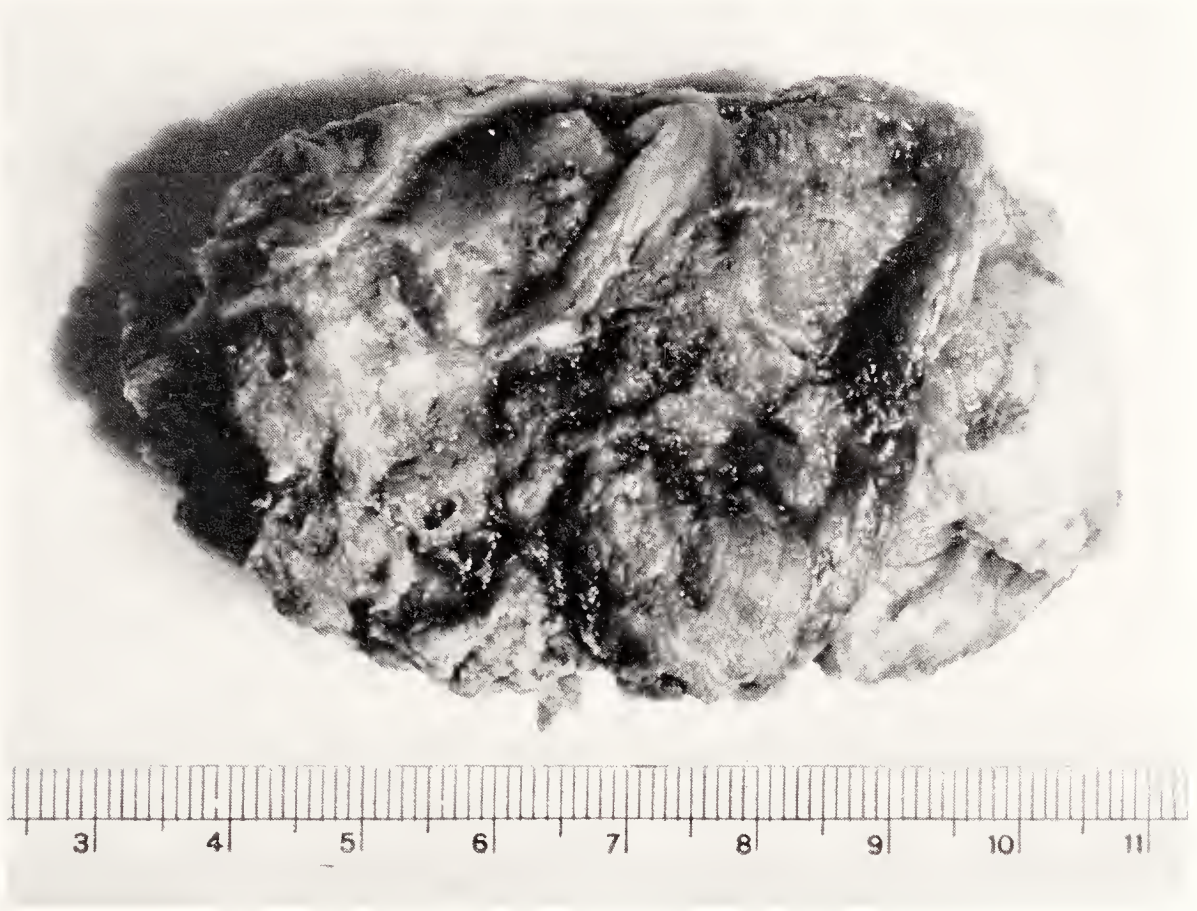
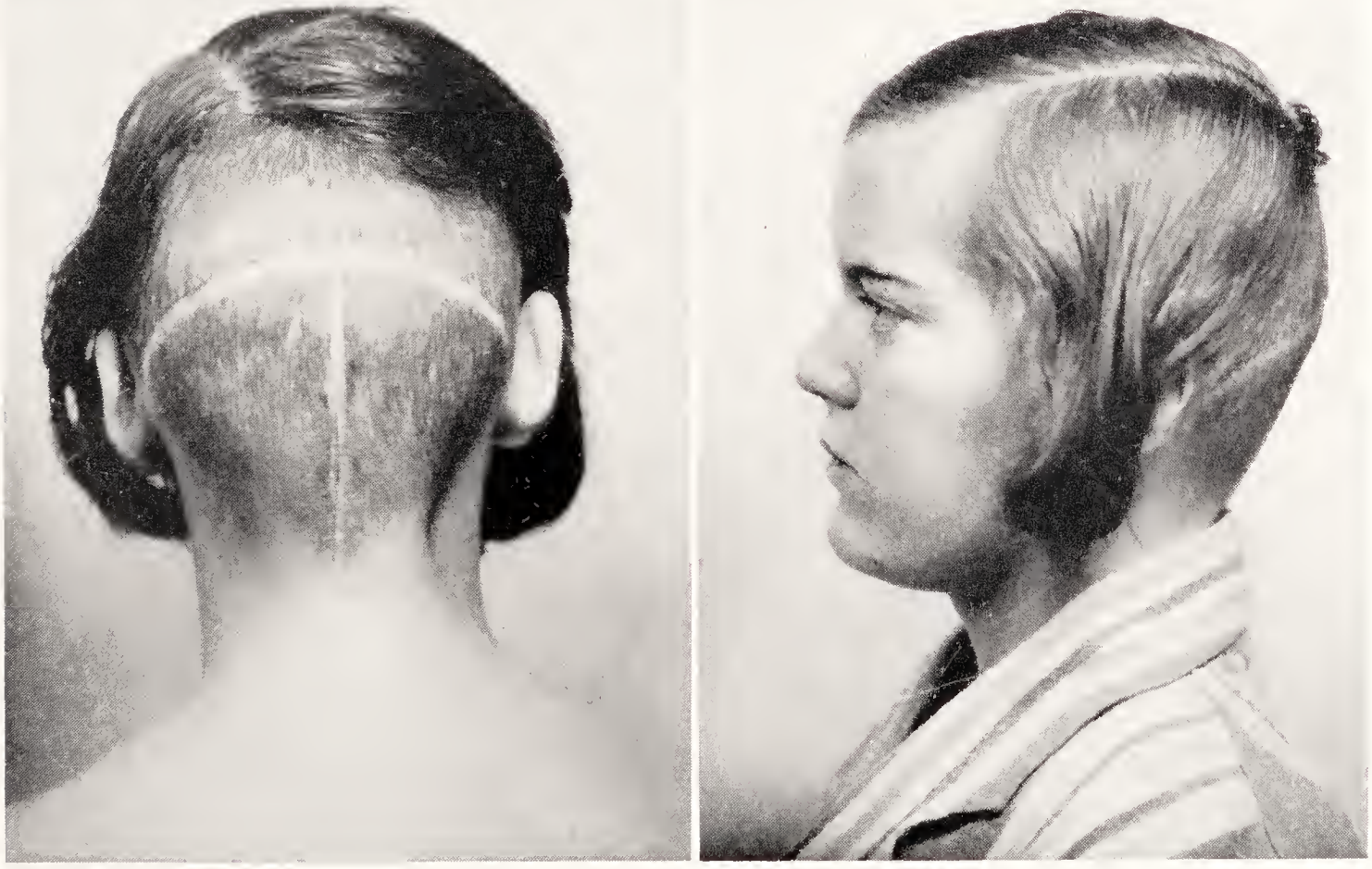


FIG. 10. The recurrent astrocytoma (nat. size) removed intact at secondary operation (*cf.* Fig. 9).



FIGS. 11, 12. Showing patient on discharge three weeks after secondary operation for recurrent cerebellar astrocytoma.

The tumours usually lie concealed beneath the cortex and may attain an enormous size. A favourite site for those of fibrillary type is deep in one of the frontal or temporal lobes; the latter are being studied by Dr. Benno Schlesinger and it would appear that their clinical syndrome is sufficiently definite to justify a reasonably precise preoperative diagnosis.

It is our custom to attack these tumours—indeed, to attack all gliomas—as radically as circumstances permit. Dr. Bailey has expressed the belief that certain gliomas are prone to become increasingly malignant if the attempt is made surgically to remove them; but even should such a change occasionally be demonstrable in a recurrent tumour (and I believe this is a matter still open to question), the relation of this to the operative

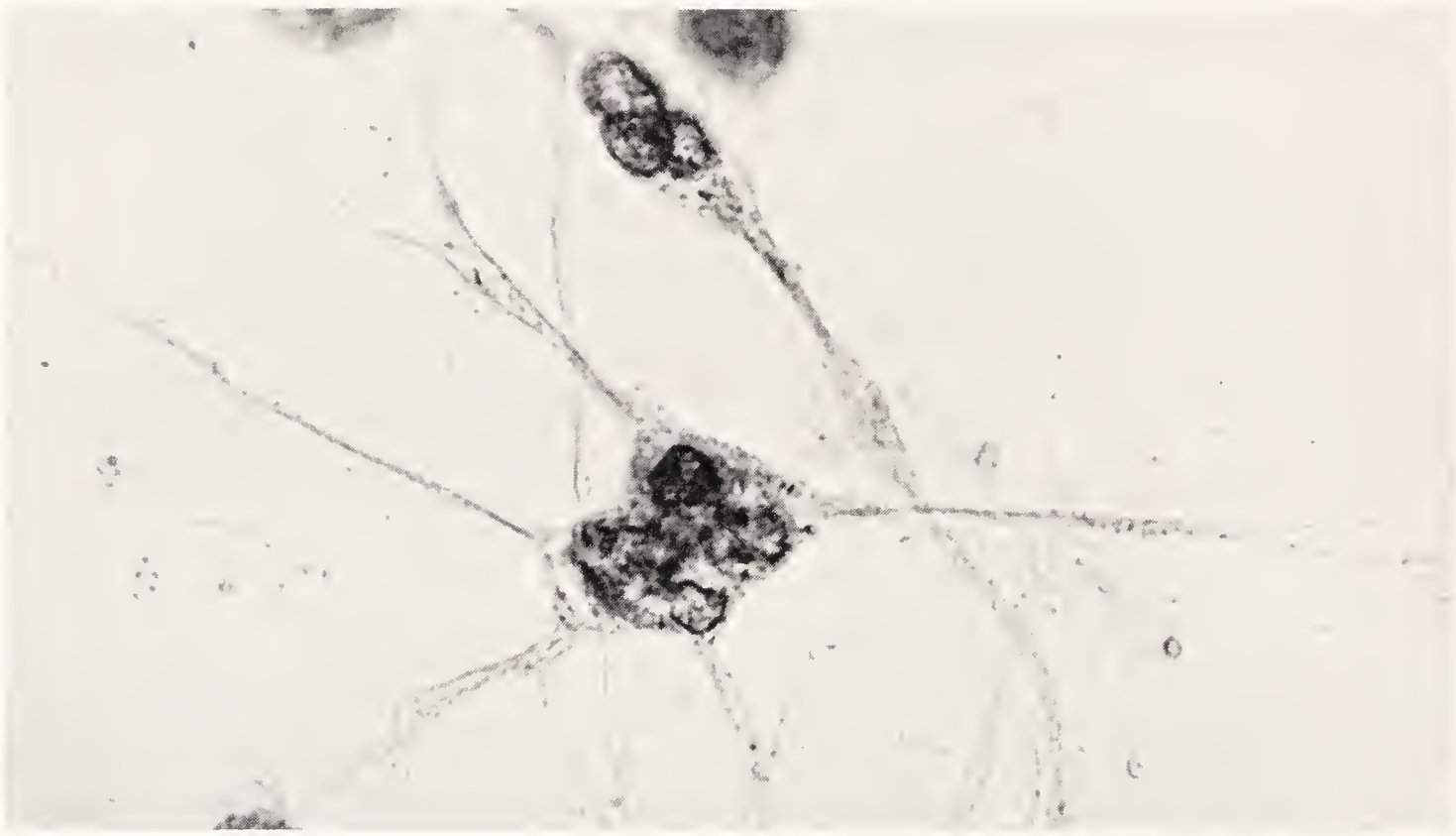


FIG. 13. Supravital preparation during operation showing two well isolated multinuclear fibrillary astrocytes with numerous processes (×850).

intervention is still something that awaits proof. As a matter of fact, it is a continual source of surprise to find that successive operations, over periods of many years for gliomas of whatsoever type, reveal each time a tumour so closely resembling the original specimen that were the dates removed from the sections they could not possibly be told apart, much less chronologically arranged. In short, there is a surprising degree of constancy from start to finish in the histological character of an intracranial tumour of given primary cytology. What is more, with the exception of certain meningiomas and of the medulloblastomas, whose cellular elements may grow by implantation when "seeded" in places remote from their primary seat of origin, most brain tumours only recur locally and expand by direct extension.

Not only for these reasons but because I strongly believe that the operative mortality is higher in the case of gliomas treated merely by decompression than it is when the growth, once exposed, is removed as com-

pletely as possible, it is our invariable rule vigorously to attack a glioma of the cerebral hemispheres rather than to withdraw from it. At the time of this writing a patient whose case may serve in illustration has just been discharged after a second operation for a recurrent cerebral astrocytoma:

The patient, a man 35 years of age (Surgical No. 35170), was first operated upon on *November 14, 1929*, eighteen months ago. He at that time gave a history of peculiar convulsive seizures of two years' duration, but it was not until four months before his admission that headaches and personality changes, chiefly shown by forgetfulness, led to his hospital admission. Ventriculograms showed displacement of the ventricles to the right and a filling defect in the left frontal horn indicating a large left frontal tumour of uncertain type.

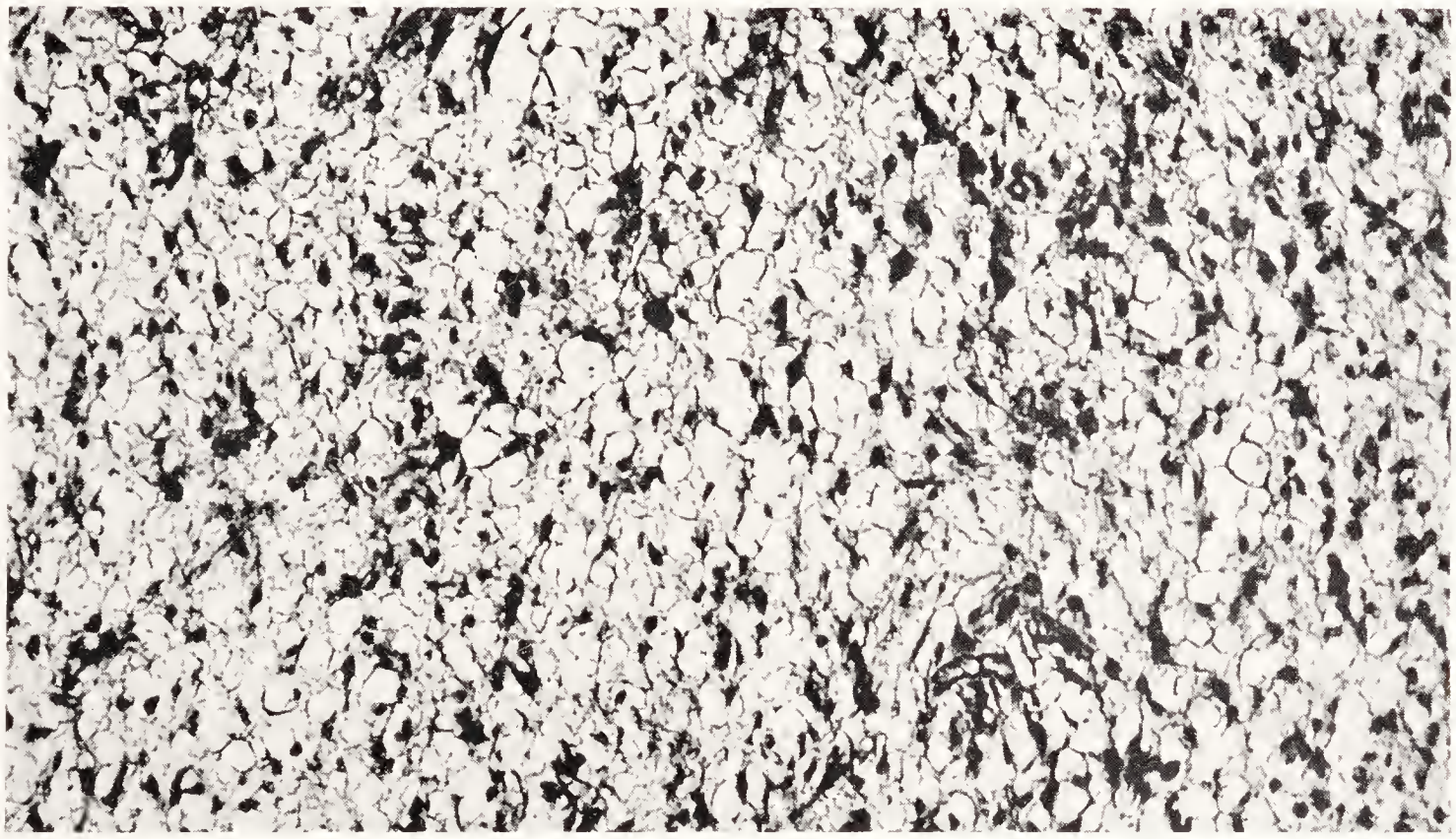


FIG. 14. For contrast with Fig. 13. Fixed-tissue section showing general architecture of the loosely meshed fibrillary astrocytoma (phosphotungstic acid hematoxylin, ×150).

At the operation conducted under local anaesthesia, a deep-lying, soft and non-cystic, greyish glioma was exposed. It was assumed to be a fibrillary astrocytoma and this was corroborated by supravital examination (Figs. 13, 14). A considerable portion of the tumour mass was removed by suction and by electro-surgical scalloping.

He made an excellent recovery, returned to his work, and apart from two convulsive attacks, one in *May 1930* and another in *March 1931*, he remained free from symptoms for eighteen months. In *June 1931*, he began to have occasional headaches and soon observed that the bone-flap was becoming slightly elevated. Realizing that this in all probability indicated a return of the growth, he applied for readmission to the hospital.

On *July 1, 1931*, at a second operation, the bone-flap was reëlevated and the entire left frontal lobe was found to be replaced by a tumour mass nearly the size of one's fist which showed precisely the same histological characteristics as before. It was removed (Fig. 15) by electro-surgical measures leaving a large

cavity over which the flap was replaced. He bore this extensive procedure without the slightest upset and was discharged (Figs. 16, 17) three weeks later with no discernible evidence of any personality change and quite capable once more of resuming his occupation for a time at least.

There may be some difference of opinion as to whether radical procedures of this type for recurring tumours are worth while. If, however, the decision could be left to the patient, as in the case of this particular man, there would be no question what he would choose to have done.

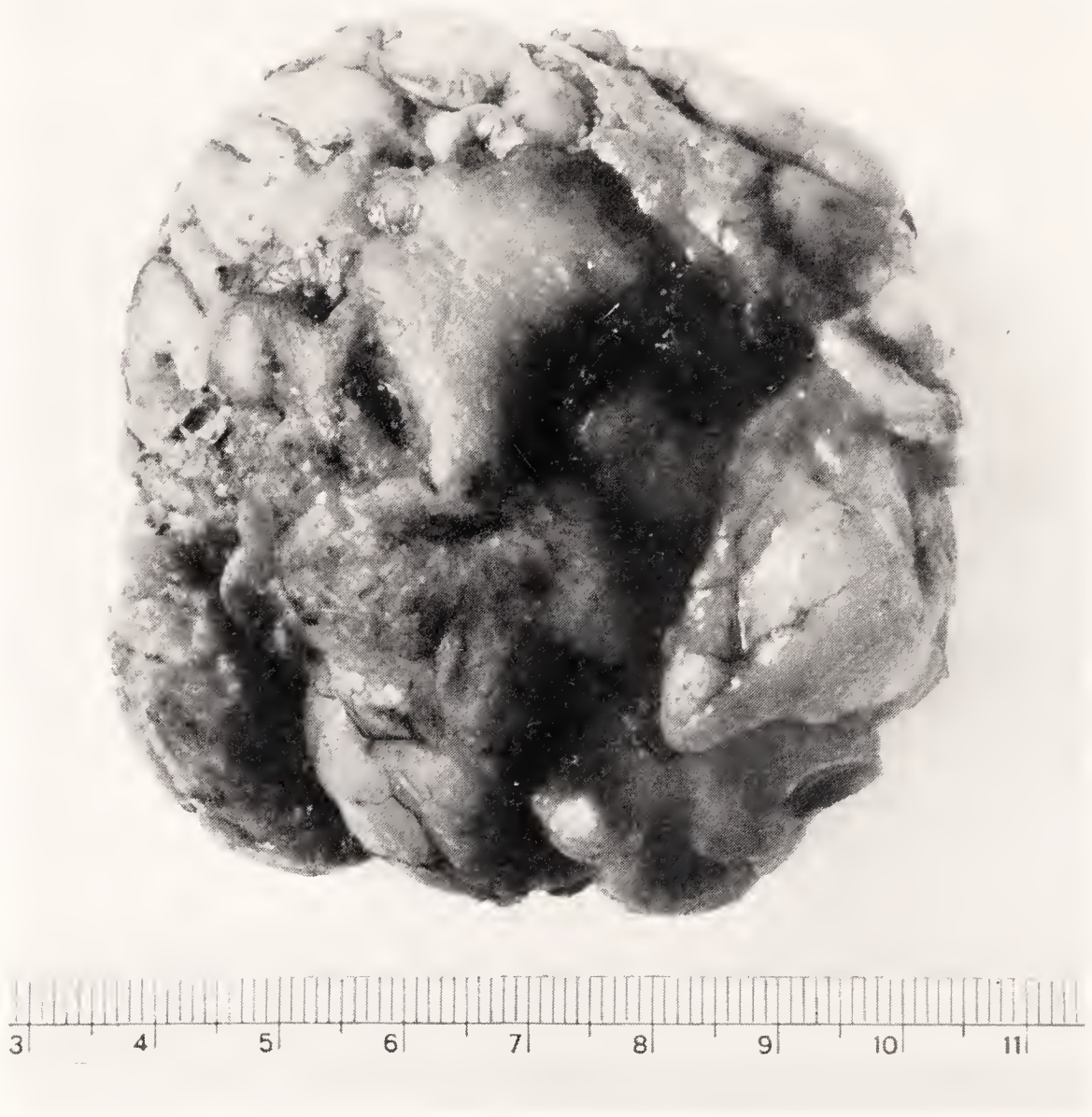


FIG. 15. Showing 118-gram tumour in gross as removed at second operation.

When tumours lie in less silent areas, and have led to paralyses or aphasia so that life if prolonged may be a burden, one may be influenced against intervention; but even under these unpromising circumstances a most surprising degree of restoration of lost function may occur when tension has been fully relieved by the radical extirpation or excavation of a tumour—even of one which may actually lie in the speech area.

Statistics.—In the group of 164 tumours diagnosed as cerebral astrocytomas, 149 have been operated upon 221 times with 23 fatalities, giving a case-mortality of 15.4 per cent and an operative mortality of 10.4 per cent. On the 41 new cases admitted during the three-year period since

July 1, 1928, there have been 52 operations with 2 fatalities giving for this later interval, a case-mortality of only 4.9 per cent and an operative mortality of 3.8 per cent.

The *combined percentages* for the astrocytomas, both cerebellar and cerebral, show for the 239 patients operated upon, 355 operations with 38 deaths, giving for the entire series a 15.9 per cent case-, and a 10.7 per cent operative mortality. In contrast, the figures for the past three year period show 86 operations on 70 patients with 3 fatalities giving for the

FIGS. 16, 17. Patient on discharge after second operation showing situation of flap.

astrocytomas regardless of situations a present day 4.2 per cent case-mortality and a 3.5 per cent operative mortality.

THE MULTIFORM GLIOBLASTOMAS

These highly malignant and rapidly growing lesions, 208 in number, have occurred without exception in the cerebral hemispheres of adults. They represent the gliosarcomas of the older terminology but their more precise nature was first clearly described by Globus and Strauss under the

designation *spongioblastoma multiforme.* For this term we perhaps unwisely have substituted "glioblastoma" in order to avoid confusing them with the polar spongioblastomas, which, from a clinical standpoint, are far more favourable tumours. The glioblastomas tend to undergo degenerative changes and probably many of the 74 gliomas which remain unclassified, because the condition of the tissue renders histological differentiation impossible, are tumours of this type. Hence, the 30 per cent of all classified gliomas represented by the 208 verified examples is in all probability too low a figure.

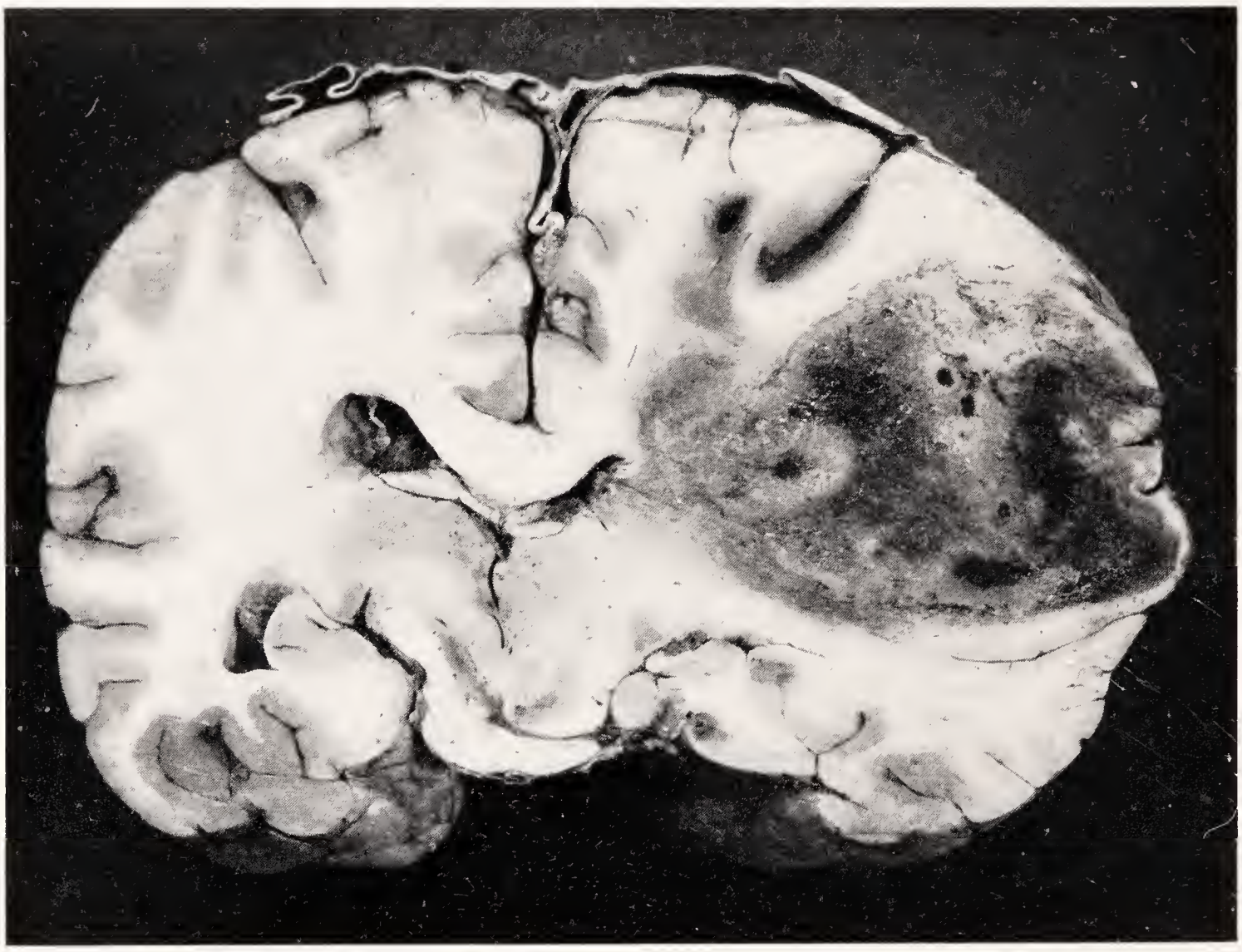


FIG. 18. A typical infiltrating necrotic glioblastoma multiforme which had come to involve the cortex. Patient comatose; death following ventriculography from failure to follow procedure by immediate operation.

Though the tumours arise in the central white matter they frequently extend out into the cortex, greatly widening the convolutions (Fig. 18), and they may even pass through the pia with formation of vascular attachments with the dura. They tend to advance along the principal nerve tracts and frequently pass by way of the callosal fibres from one hemisphere across to the other. The bilateral "butterfly" tumours of the corpus callosum are often of this type. Not infrequently the tumours on reaching the surface so greatly expand a single convolution that the growth has the appearance of being sharply outlined and enucleable (Fig. 19); but if enucleation is attempted, one soon finds that in the depth of the brain the

growth passed into the normal tissues with no appreciable line of demarcation.

In spite of their infiltrating character, it is our custom to attack these tumours vigorously by a combination of block extirpation aided by suction with electrical scalloping. When the tumour has attained a considerable size, its central portion has usually become so necrotic and broken down it is easily removed by suction; and when in this process one reaches the vascular periphery, the vessels of the marginal sulci which project into

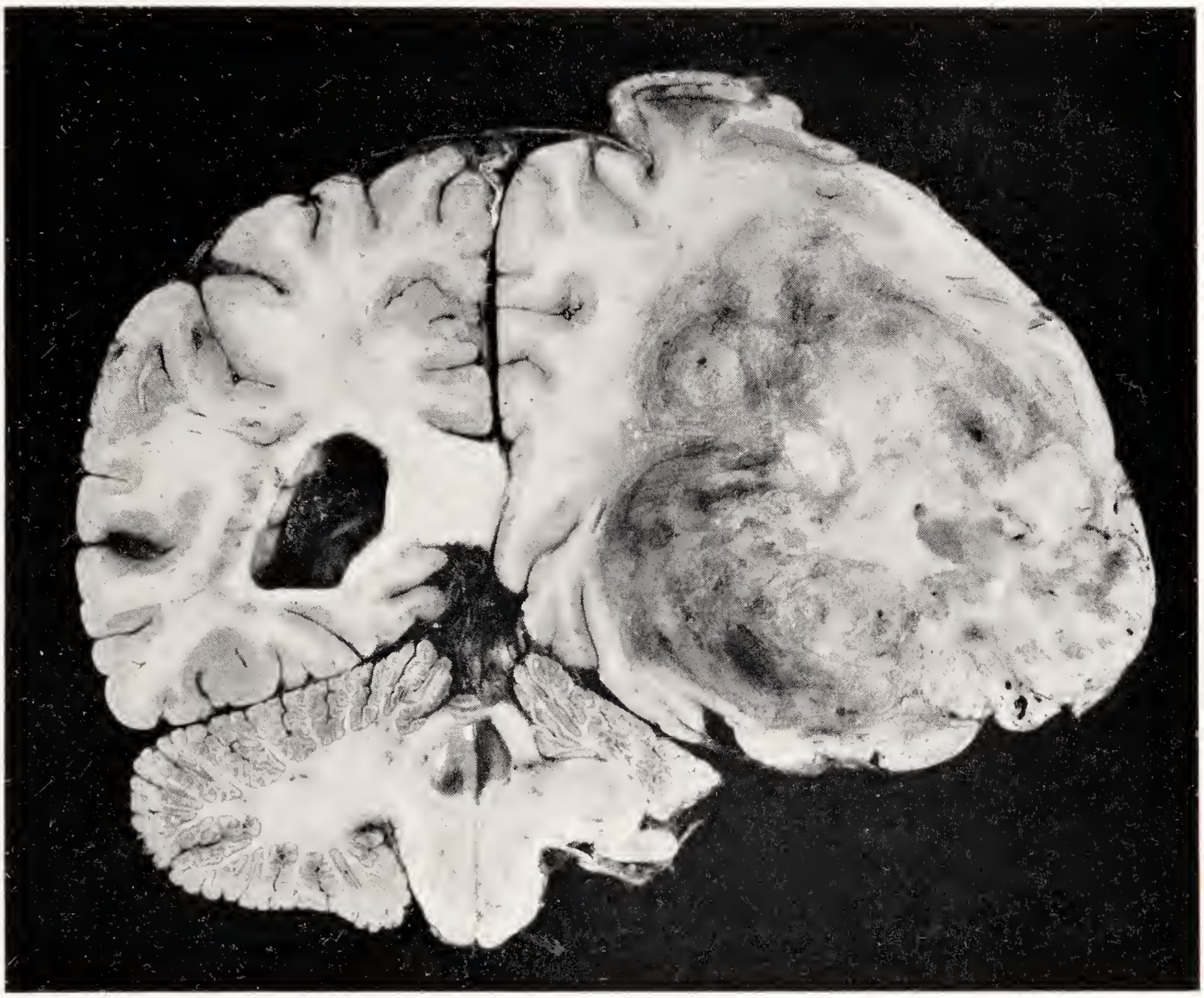


FIG. 19. Glioblastoma multiforme of right occipital region with appearance of enucleability. Decompression without tumour removal at another clinic. Patient brought to hospital *in extremis* and died without secondary operation. Note fairly well circumscribed tumour.

the tumour are drawn up into and bleed into the glass "sucker" and can be easily secured by the placement of a silver clip at its mouth.

The larger and more formidable the lesion appears to be, the more radical is the effort made to remove its major portion. The reason for so doing differs in no way from that given in speaking of the cerebral astrocytomas (pp. 22–23 of preceding section), for though only a relatively short span of from six to nine months may be expected before there are signs of recurrence, the respite may be one for which both patient and

relatives are deeply grateful. I have known many people in the interval to complete important pieces of work in which they had been engaged before they were taken ill. In illustration:

A middle-aged business man of large affairs was suddenly taken with headaches which were ascribed to nervous indigestion. He was supposed to be physically run down and finally was persuaded to go south for a winter's rest. He did not improve and began consulting a series of doctors, no one of whom could tell what was wrong until his vision began to be impaired. An ophthal-

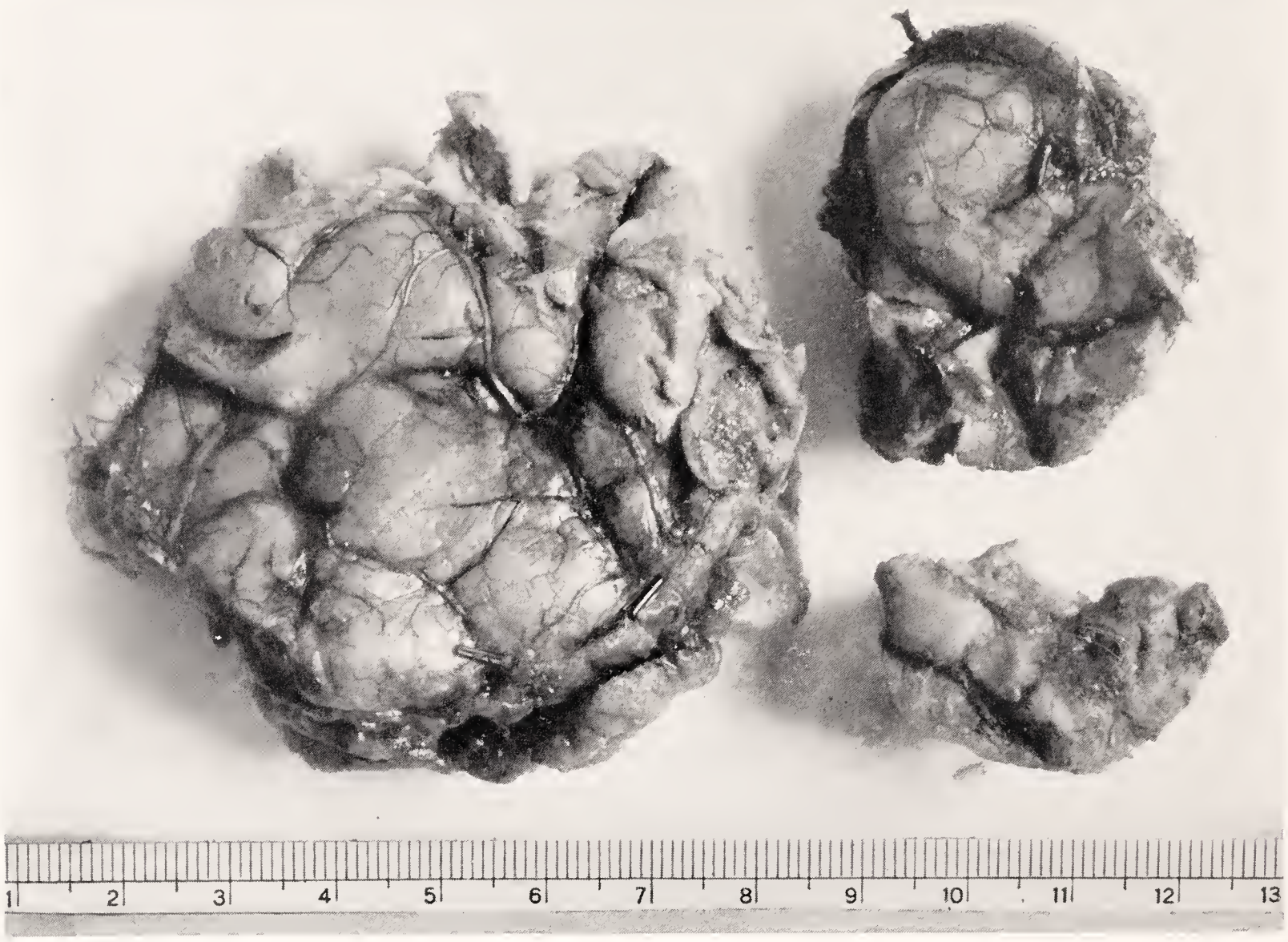


FIG. 20. Showing cortical surface of typical specimen of glioblastoma of temporal lobe blocked out by electro-surgical methods and in this instance removed in three fragments.

mologist then discovered a bilateral choked disc and a partial left homonymous hemianopsia. Four months had elapsed from the onset of symptoms.

The diagnosis was made of a right temporal lobe tumour and at operation a glioblastoma involving the major part of the lobe was found. This was electrically extirpated in mass, a practically complete lobectomy being necessary (Fig. 20). The bone-flap was replaced leaving a subtemporal decompression.

Recovery from this operation was highly satisfactory with complete freedom from symptoms for the next six months. He meanwhile straightened out his business affairs, which were in a tangle because of his long absence, made his will, and for the first time in many years went off with his wife and children

for a long summer vacation in the Canadian woods. From all accounts, they had never before had so happy and peaceful a time together.

At the end of six months symptoms had begun to recur; a secondary operation was performed with partial symptomatic relief for another three months. He then grew indifferent to his condition, became increasingly somnolent, and died peacefully ten months from the time of the first operation.

In order to give even so brief a respite as this not only must enough tumour be removed completely to relieve intracranial tension, but it is

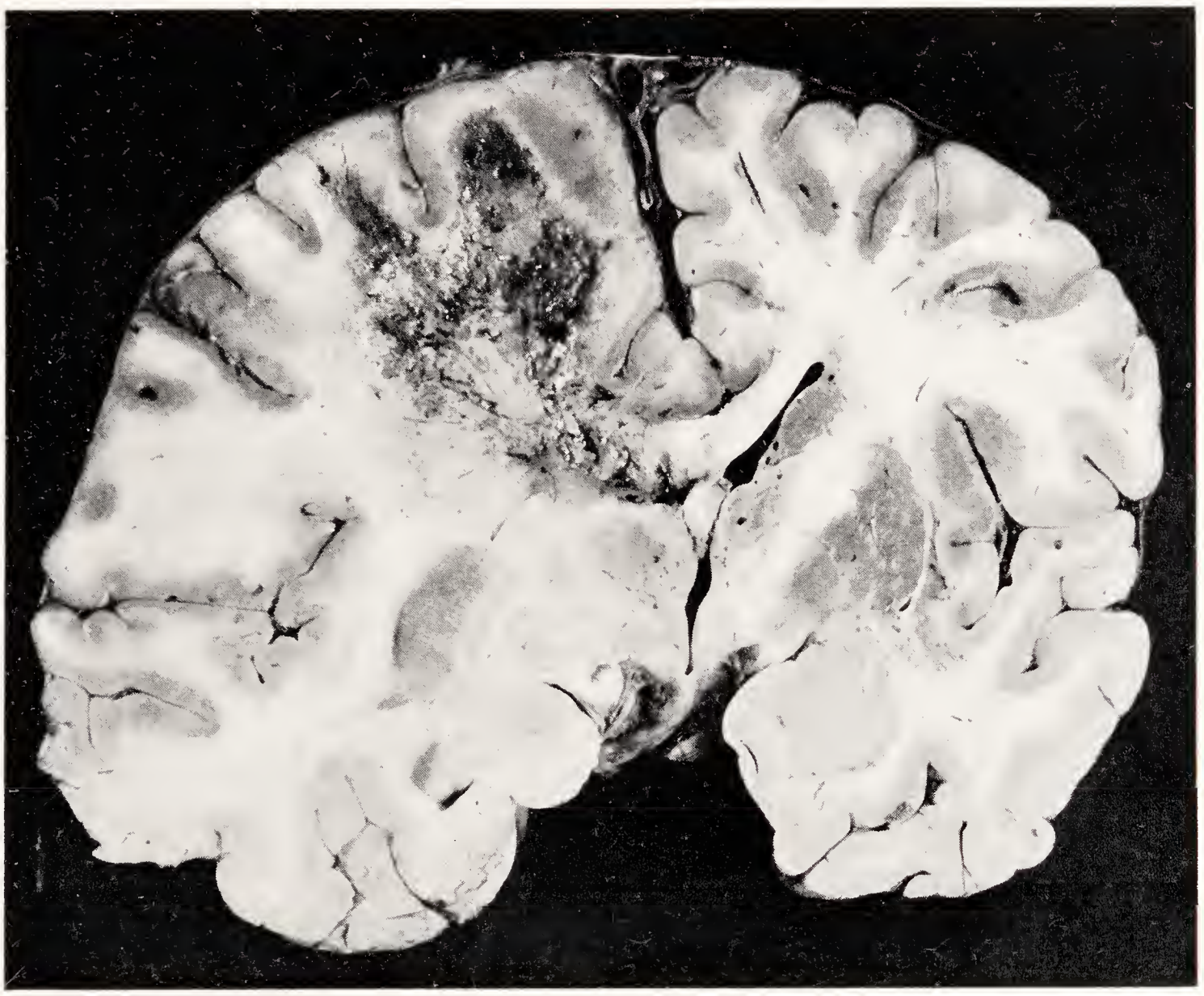


FIG. 21. Example of a surgically unverified glioblastoma multiforme, to show its limitation to the white matter and tendency to spread toward the corpus callosum.

our frequent practice in addition to the subtemporal defect to remove the lower third of the bone-flap to afford relief from pressure for as long a time as possible. What may be expected of one of these tumours when merely decompressed is shown by the following case in which the growth was not disclosed at operation, the diagnosis on the patient's discharge having been "tumour unverified, presumptive glioma."

A mechanic 44 years of age (Surgical No. 32599) was admitted *November 6, 1928*, with a left-sided hemiparesis associated with convulsive movements of the right arm of five weeks' duration. Examination showed nothing more than the

hemiparesis with hyperactive reflexes. There was only a beginning papilloedema. Speech and intellect were unimpaired possibly because the man had familial left-handedness.

At operation on *November 8*, the tumour was not disclosed and an attempt to puncture the ventricle was unsuccessful. He was discharged a month later, on *December 6*. In spite of the decompression, symptoms rapidly advanced and his death was reported on *January 9, 1929*. The brain was forwarded to us for study. The lesion was confined, as can be seen (Fig. 21), to the corona radiata.

Other tumours, which have not undergone much central degeneration and which appear to have an outer shell of polar spongioblasts, may be highly deceptive in appearance and be enucleated apparently intact, their true histological nature coming as a surprise. I may give an example:

FIG. 22. The enucleated tumour showing the smooth subpial surface above.

A man 45 years of age (Surgical No. 37317), admitted on *September 20, 1930*, had had symptoms suggesting tumour of only eight weeks' duration. He was found to have a right homonymous hemianopsia, a high choked disc, hemiparesis in the right side, and aphasia. It was impossible clinically to tell whether the lesion was temporal or occipital but ventriculograms showed it to be parieto-occipital.

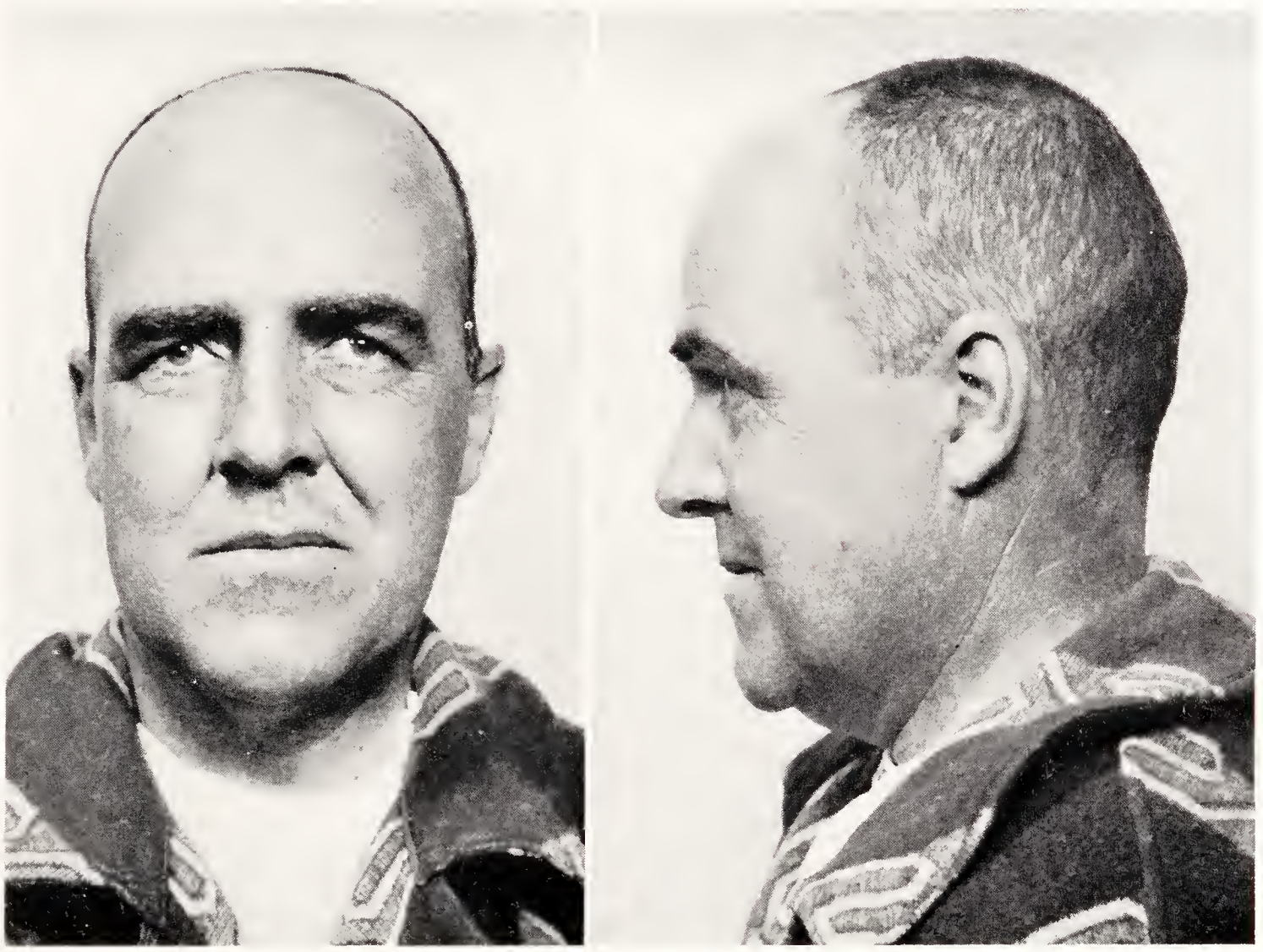
At operation on *September 30*, a large definitely enucleable tumour was exposed and, by electro-surgical dissection, easily dislodged, apparently in its totality. The tumour mass (Fig. 22) weighed 109 grams. When examined in the fresh by supravital technique the predominating cells were polar spongioblasts. Only one mitotic figure was seen. A reasonably favourable prognosis was therefore given.

He made an excellent recovery from this operation with disappearance of his hemiplegia, aphasia and hemianopsia by the time of his discharge (Figs.

23, 24) on *October 24*. He resumed his occupation as a foreman. He was seen again on *December 11* and *January 22* and *April 1, 1931*, when he was quite free from symptoms. He had been given no postoperative radiotherapy.

A further study of the tumour after fixation had meanwhile led first to a tentative diagnosis of astroblastoma and finally to that of an unmistakable glioblastoma multiforme. It was therefore no surprise to learn that evidence of recurrence had set in during *May* and his death without autopsy was reported in *July*—an interval of only ten months following the operation.

It is customary thoroughly to radiate these tumours after operation and there can be no doubt but that the X-rays have a temporary checking



FIGS. 23, 24. Patient on discharge after mass extirpation of large left parieto-occipital glioblastoma.

effect on the activity of the growth. An unusually favourable example of this is as follows:

A professional roentgenologist, 44 years of age (Surgical No. 17165), was admitted *August 15, 1922*, with symptoms of only three months' duration—headaches, aphasia and convulsive seizures suggestively uncinate in character. At operation, *August 19, 1922*, a large tumour was found in the supramarginal region which, for that time (ten years ago), was treated by a fairly radical extirpation.

He made an excellent recovery and before his discharge was given a series of X-ray treatments. Two months later he resumed his professional work with his accustomed vigour and interest. He subsequently in his own office subjected

himself to roentgeno-therapeutic treatments which even in the absence of any return of symptoms were persisted in during the next two and a half years. By *June 1925*, there were unmistakable signs of recurrence which obliged him finally to abandon his work and reënter the hospital in hope of further surgical relief.

By this time his decompression was bulging considerably and he had a fairly well marked motor aphasia. On *December 9, 1925*, the flap was reëlevated disclosing a recurrent growth which was again partly extirpated. Owing to its atrophic and cicatricial condition, due to the excessive radiation, the scalp was found difficult to close with the usual accuracy and a cerebrospinal fistula developed which refused to heal. Finally in desperation on *February 12, 1926*, the entire wound was reopened and the bone-flap sacrificed permitting a much more secure wound closure than before. He succumbed five days later. At the post-mortem examination very little residual trace of his tumour was found.

A three-year interval before symptomatic recurrence in the presence of a glioblastoma multiforme is most exceptional; and though a favourable result such as this may occasionally follow radiation, I sometimes feel that the consequent loss of hair and bedraggled appearance make this therapeutic measure scarcely worth the inconvenience to the patient and time to the roentgenologist. Then, too, it is highly disconcerting when a radio-therapeutic session seems suddenly to stimulate a growth which has for a time apparently been inactive, and this is far from an uncommon experience. Patients usually ascribe their period of relief solely to the operation and on signs of recurrence they customarily beg for a secondary operation; and these appeals are sometimes difficult to refuse even though the surgeon (if he is certain of the diagnosis) is well aware the respite at best will be much shorter than before.

It is of course fully understood that, if every malignant glioma is surgically attacked on signs of recurrence and of re-recurrence, the last operation will be certain to end in a postoperative fatality in hospital so that were this plan followed a 100 per cent case-mortality would be wholly legitimate.

Statistics.—An analysis of the full series has just been made by Dr. Leo J. Adelstein. Of the 208 tumours to July 1, 1931, 25 were disclosed at autopsy without preceding operation. The remaining 183 patients were operated upon 272 times, 51 of them twice, 16 three times, and 2 four times for recurrences, with 66 postoperative deaths. The case-mortality has therefore been 36.1 per cent and the operative mortality 24.2 per cent.

During the three-year period from July 1, 1928, to July 1, 1931, these particular tumours when exposed have so far as possible routinely been extirpated by electro-surgical measures. In this period there have been 73 new cases with 120 operations and 17 postoperative deaths giving a 23.3 per cent case-mortality and a 14.1 per cent operative mortality. In the last consecutive 50 glioblastomas the operative mortality has only been 11.6 per cent a reduction compared with that for the entire series of more than half.

THE MEDULLOBLASTOMAS

These gliomas which come next in the order of frequency should be separated, like the astrocytomas, into their cerebellar and cerebral types for in the two situations they differ so greatly in their character and behaviour they may well enough be regarded as different tumours in spite of their histological similarity.

The cerebellar types.—These were first described with Bailey in 1925;[22] and two years ago a critical review of the examples in the series

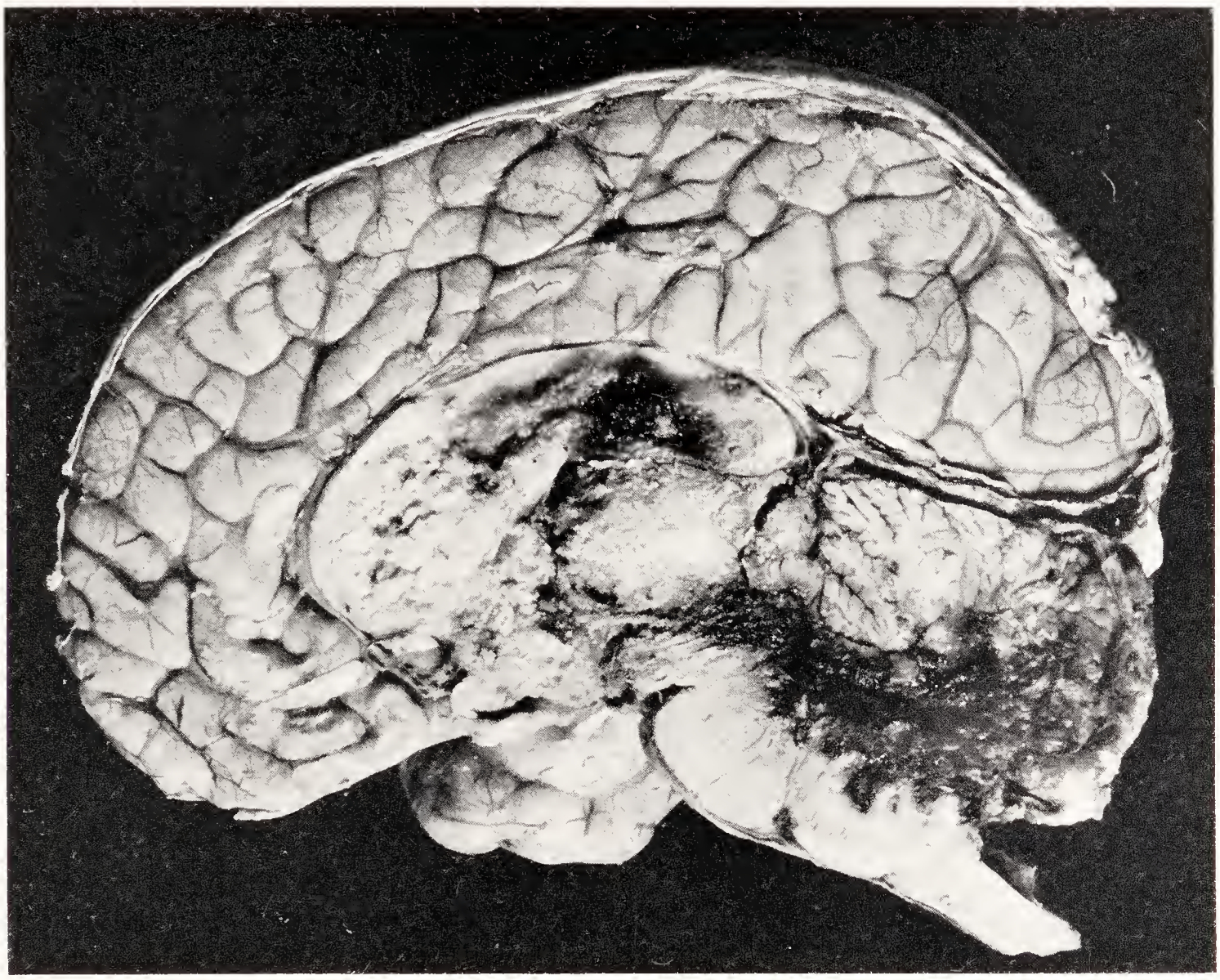


FIG. 25. Medulloblastoma series (Case 50): postoperative death following secondary operation after two-year interval. Case thoroughly radiated. Note invasion of medulla and massive obliteration of cerebral ventricles by tumour.

up to July 1929 was made and published.[23] Like the astrocytomas, they are commonly found in the midcerebellar region of children, but they differ in being highly malignant, rapidly growing lesions, which are prone to inoculate the cerebrospinal fluid and spread widely by implantation in its spaces.

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[22] Bailey and Cushing. Medulloblastoma cerebelli: a common type of midcerebellar glioma of childhood. Arch. Neurol. & Psychiat., 1925, XIV, 192–223.

[23] Cushing, H. Experiences with the cerebellar medulloblastomas. A critical review. Acta Path. et Microbiol. Scand., 1930, VII, 1–86.

Of all intracranial tumours, they are the most susceptible to the effects of radiotherapeusis. However, at the best, this form of treatment merely serves to postpone the inevitably fatal outcome no matter how complete the original surgical extirpation of the tumour may appear to have been. The longest survival period in any case in the series was five years, four operations for local recurrences having been performed in the interim. Spinal metastases are common[24] and the ventricles before the end may come to be solidified with tumour (Fig. 25) in spite of persistent radiation.

Given a child with a syndrome of morning vomiting, suboccipital headaches, enlarging head, choked discs, and cerebellar instability, one may have reason to expect a midline cerebellar tumour, though it is not always easy to foretell before operating whether a medulloblastoma, an astrocytoma or, indeed, an ependymoma will be encountered. Radiation cannot serve as a differential test, for the astrocytomas are not only unaffected by the X-ray so far as we can determine, but they often show periods of spontaneous amelioration which might easily be misinterpreted as a beneficial effect of radiation. What is more, we have seen serious disturbances from radiating medulloblastomas which have forced us not infrequently into emergency operations.

It therefore is my present feeling in regard to these midcerebellar tumours of whatsoever kind that an operation rather than preliminary radiation is indicated; and the earlier this is done, the better, for procrastination, particularly in the case of the astrocytomas, is apt to be penalized by blindness. Should no surface lesion be disclosed at the operation, a median incision of the vermis is the most likely way of bringing a concealed growth into view. Even then, in the absence of a large cyst which usually betokens an astrocytoma, one cannot always be sure whether the tumour when exposed is a medulloblastoma or an astrocytoma, for they have much the same outward appearance and both may be soft lesions. But even should the growth be unmistakably a medulloblastoma, or so prove to be on supravital examination, I believe that its thorough local removal by dissection or by suction is the proper procedure.

There is a risk—possibly a certainty—of inoculating the cerebrospinal fluid spaces by these manipulations; but on the other hand it is the most certain way, by overcoming the hydrocephalus, of giving immediate symptomatic relief, which for most of these cases is urgently demanded. Radiation should subsequently be begun as early as possible and it should be distributed over the entire cerebrospinal axis. By this combination of radical extirpation and radiation a complete subsidence of all symptoms for a year and sometimes longer may be anticipated. The last case in the series, which is a typical one, may be briefly cited in illustration:

A boy five years of age (Surgical No. 37260), was admitted *September 11, 1930,* with a history of three months of vomiting (leading to an appendectomy),

[24] Bailey, P. Further notes on the cerebellar medulloblastomas. The effect of roentgen radiation. Am. J. Path., 1930, VI, 125–136.

one month of suboccipital headache, double vision and increasing instability. He was found to have a 3 diopter choked disc, evident hydrocephalus and typical cerebellar ataxia without nystagmus. The clinical diagnosis of midcerebellar tumour, probably medulloblastoma, was made.

On *September 19*, under avertin anaesthesia, in the course of the usual bilateral suboccipital procedure, a tense cerebellum was exposed with no widening of the vermis or surface evidence of tumour other than for a single typical isolated surface metastasis (Fig. 26). The vermis was vertically transsected disclosing a soft median tumour which was thoroughly sucked out leaving the floor of the IVth ventricle widely exposed. The tumour was unusually vascular and a visible fragment of it was left in the depth adhering to the right margin of the ventricle. This residuum was thoroughly coagulated as was also the surface metastasis before closing the wound.

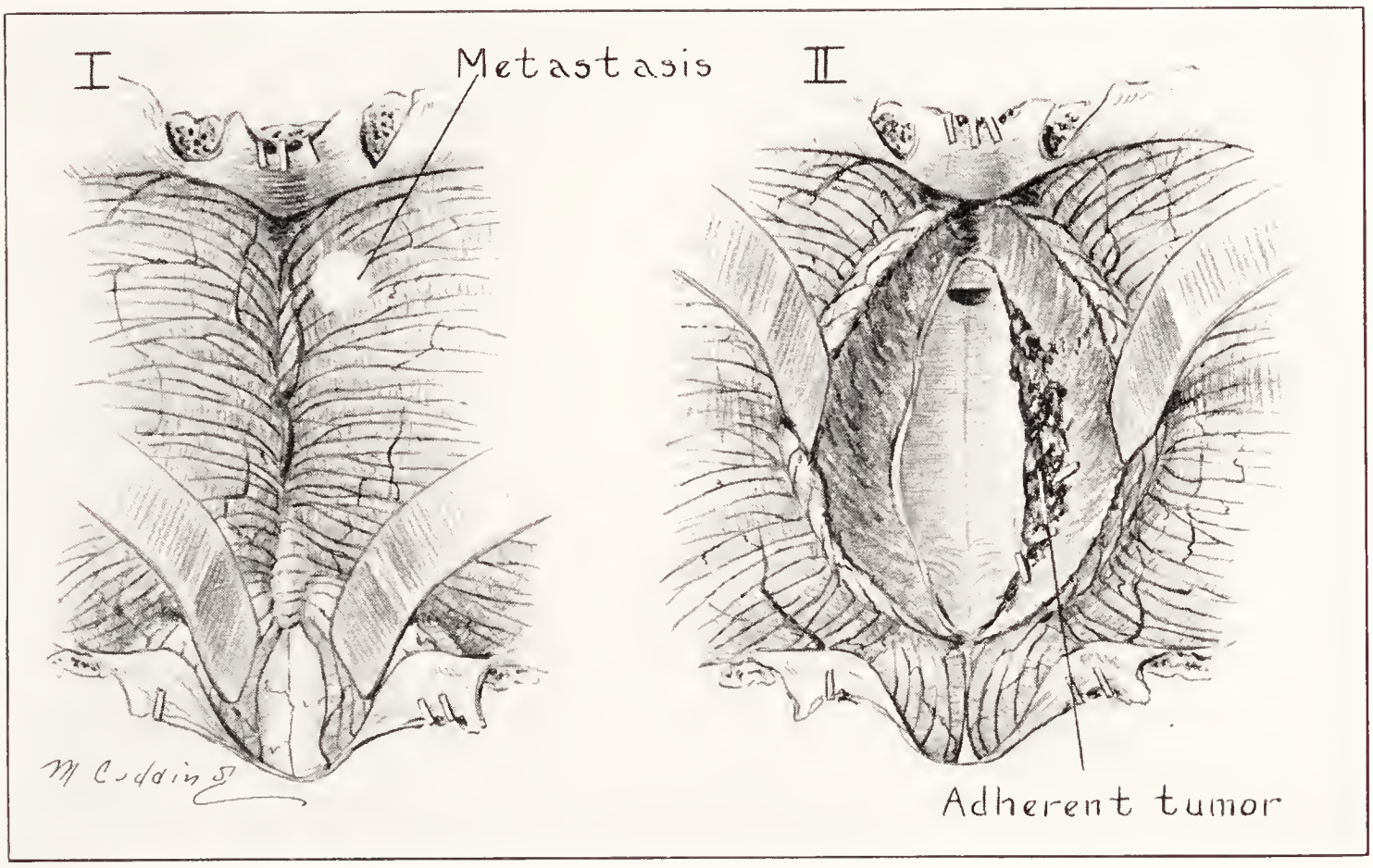


FIG. 26. Operative sketches showing typical surface metastasis of medulloblastoma and customary appearance of field after radical extirpation chiefly by suction.

The tumour when examined in the fresh was a typical medulloblastoma (Fig. 27) containing many clasmatocytes, a few spongioblasts, and abundant mitoses.

During convalescence six radiotherapeutic treatments covering the entire cerebrospinal axis were given. The child was discharged on *October 11*, (Figs. 28, 29) with normal fundi and in excellent general condition. Since then, at practically two-month intervals, he has had further radiotherapeutic exposures and at the present writing, *August 1, 1931*, eleven months since his operation, he is having his fifth series even though he is now in perfect health and leading the active life of an apparently normal child.

The cerebellar medulloblastomas which occur later in life, and which are more often laterally placed, appear to be somewhat less malignant and the few patients still living are mostly adults. The operative mortality

has been extremely high. This has been due largely to the radical and possibly misjudged efforts we have made, while studying the life history of these lesions, wholly to extirpate them with the resultant wide exposure of the floor of the fourth ventricle.

Statistics.—The 68 cerebellar cases of which number 64 have been operated upon 99 times with 25 postoperative deaths give a 39.0 per cent case-mortality and a 25.2 per cent operative mortality, the highest by far

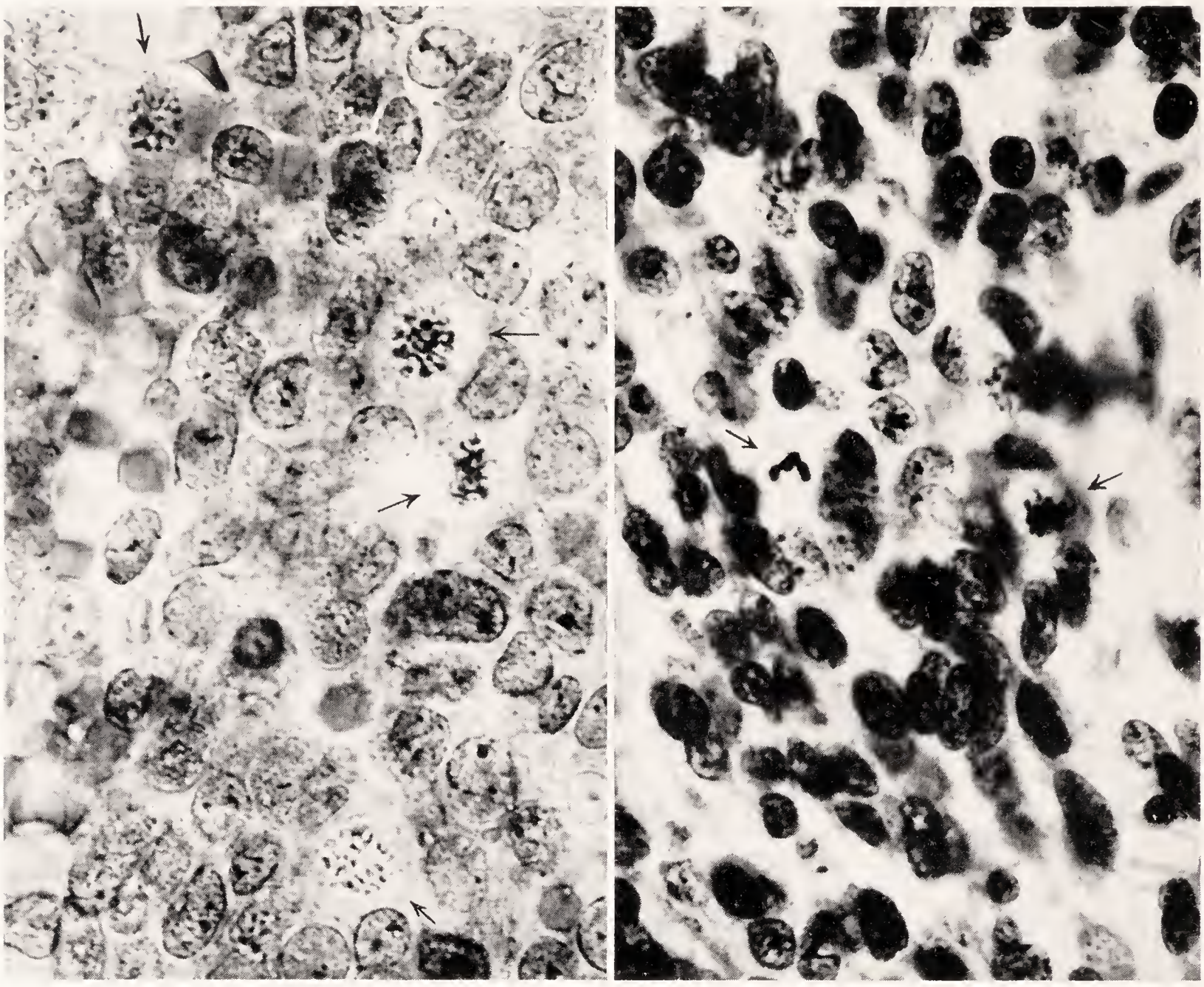
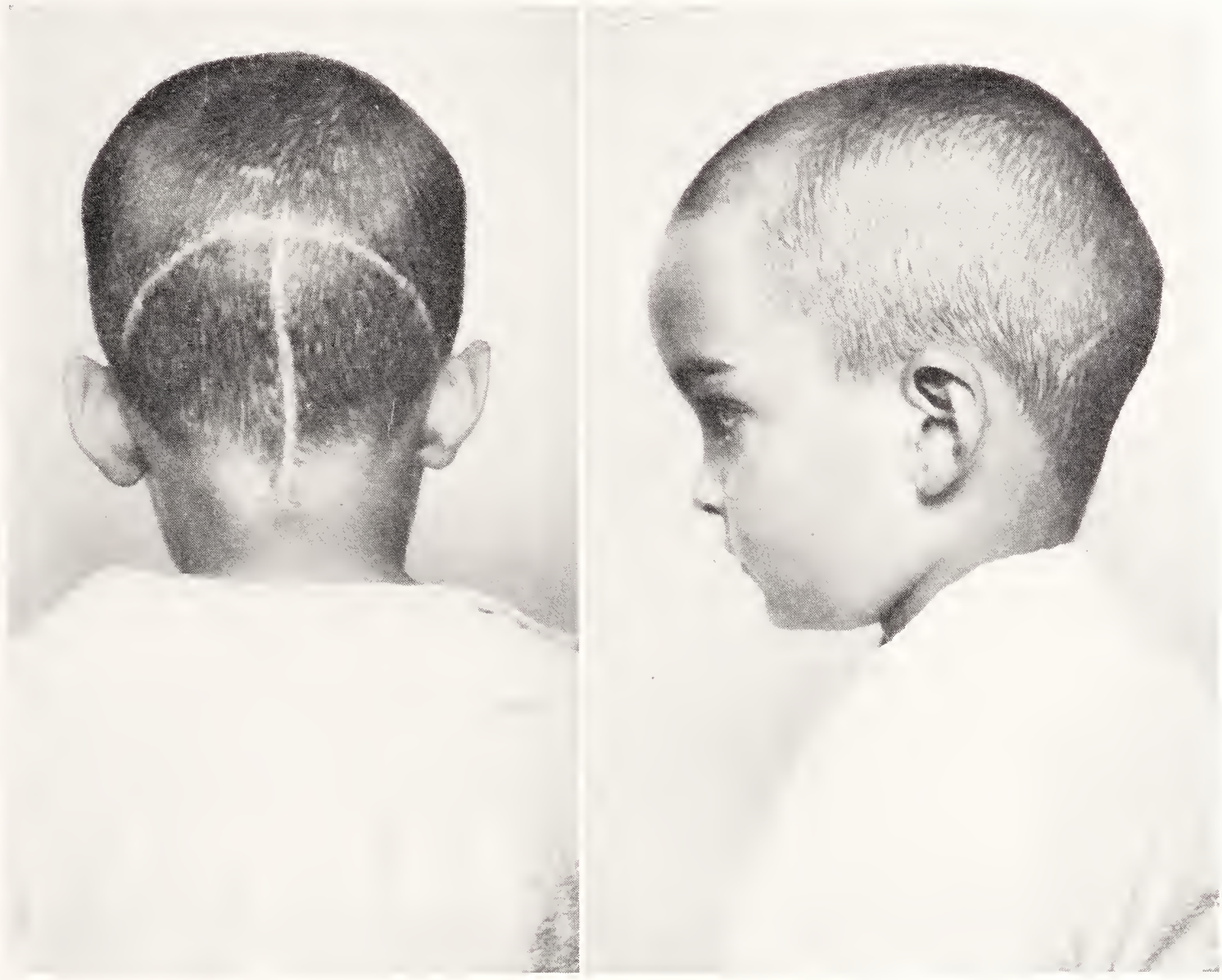


FIG. 27. Photomicrographs (×850) of medulloblastoma mentioned in text: on left, the supravital preparation with four mitotic figures indicated by arrows; on right (for comparison) the Zenker-fixed-tissue preparation stained with phosphotungstic acid hematoxylin showing two mitotic figures.

of any tumours in the series whose life history is so well understood. The figures are inappreciably modified for the 15 cases with 19 operations and 5 postoperative deaths in the last three-year period, giving for the cerebellar medulloblastomas a present-day 33.3 per cent case- and a 26.3 per cent operative mortality.

The cerebral medulloblastomas.—As was made clear in the critical review to which allusion has been made,[22] there were at that time eleven

tumours of the cerebral hemispheres which had come to be diagnosed as medulloblastomas, and to this number seven more have since been added. Though they may also occur in childhood, they are tumours principally of adult life; they are apt to be fairly well encapsulated lesions and may attain an enormous size—almost replacing a hemisphere; they almost always show spotty calcification on X-ray films; they are not so prone as the cerebellar tumours rapidly to recur, only one of them having come to inoculate the cerebrospinal spaces and to spread in this way.



FIGS. 28, 29. Patient on discharge three weeks after operation for medulloblastoma.

In short, the cerebral medulloblastomas are for the most part relatively benign lesions with a life history very similar to the oligodendrogliomas (to be described in a later section) which also happen to be equally prone to undergo calcification. It is possible, indeed, that they may be akin to these tumours, and it must be admitted that the cells of an oligodendroglioma when examined in the fresh by the supravital method might easily be mistaken for medulloblasts (*cf.* Figs. 27, 45). They represent, therefore, tumours which it is unsafe to classify on their microscopic appearance alone; for even though they may appear to have the same histogenesis as the cerebellar medulloblastomas, the tumours in the two situations differ widely in their bio-behaviour. And this, to repeat, is what the

surgeon needs to know about the tumour he has exposed regardless of what the neuropathologist decides to call it.*

Our vacillating position in regard to the histogenesis of most of these cerebral "medulloblastomas" is shown by the fact that in our glioma monograph[11] (1926) three tumours in the collection were described as neuroblastomas—indeed, they had so interested us that the clinical histories of the three cases were given in full; and in his independent papers a year later Dr. Bailey[25,26] drew wholly upon these cases for his illustrations of neuroblasts. However, by this time (1927) he had chosen to omit the neuroblastomas—along with one or two other types—from his original glioma subdivisions. Accordingly, the neuroblastomas, of which several other examples had been identified in the interim, were reclassified either as medulloblastomas, as neuro-epitheliomas, or as atypical and unclassifiable gliomas.

This reallocation of the "neuroblastomas" has not only been confusing from the standpoint of nomenclature, but has served to scatter in several groups a considerable number of surgically favourable tumours which in all certainty must be closely related to one another. Another element which adds to the confusion is the supposition that, like the cerebellar medulloblastomas, these cerebral tumours have been beneficially influenced by radiation whereas the slowness of growth shown by many of them makes this impossible to determine. One of the patients, who lived for six years after two operations, had been given during this interval three X-ray treatments and his long survival was cited by Bailey, Sosman and Van Dessel[27] as "probably a direct result of the roentgen therapy."

Unquestionably these and other correlated cerebral tumours need further detailed study and for clinical reasons if for no other many of them deserve to be put in a separate category. The following is an example of an histologically unmistakable medulloblastoma of the cerebrum:

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* In our re-examination two years ago of the medulloblastoma specimens in the collection it was found that among the cerebral tumours so classified one was unmistakably an oligodendroglioma which had been reverified as such at a secondary operation, while others, in a groping effort to find some proper designation for them, had been called at one time or another *neuroblastoma*, *neuro-neuroblastoma*, *medulloblastoma neuromatosum*, and *spongioblastoma neuromatosum*.

In a recent paper (La Presse Médicale, July 4, 1931, 977–981), Roussy, Oberling and Raileanu describe, under the name of *neurospongioma*, 15 cerebellar tumours from persons of various ages which they regard as identical with our medulloblastomas. These tumours showed the same abundance of nerve fibres which we have encountered in our cerebral so-called "medulloblastomas" but have never seen in the cerebellar cases even though an occasional neuroblast and spongioblast may be detected in many of them. The term *neurospongioma*, which at least is far more convenient than *spongioblastoma neuromatosum*, is likely to find favour for lesions of this particular type whether they occur in cerebrum or cerebellum.

[25] Bailey, P. Further remarks concerning tumors of the glioma group. Bull. Johns Hopkins Hosp., 1927, XL, 354–389.

[26] *Idem*. Histologic atlas of gliomas. Arch. Path. & Lab. Med., 1927, IV, 871–921.

[27] Roentgen therapy of gliomas of the brain. Am. J. Roentgenol., 1928, XIX, 203–264. (Case I.)

A married woman, 46 years of age (Surgical No. 367), was admitted on *September 2, 1913*, with the following history: In *February 1910*, she had begun to show definite tumour symptoms with convulsive seizures, a left hemianopsia, and gradually increasing left hemiparesis. In *May 1911*, her local surgeon had undertaken to make a right-sided subtemporal decompression but a fungus cerebri developed with wound infection and a long drawn out convalescence was the consequence.

At the time of her admission she was comatose and having frequent convulsive seizures. A huge, soft, bulging mass in the right temporal region was associated with a left-sided spastic hemiplegia and secondary optic atrophy.

The outlook was desperate but nevertheless on *September 5, 1913*, a large right-sided osteoplastic flap was turned down disclosing an extremely tense brain; this extruded and ruptured so soon as the dura was reflected disclosing a huge, apparently enucleable soft gliomatous tumour. This great mass which was said to look "as though another small brain was encased within the brain proper" was enucleated largely by finger dissection. It was described as being the size of a fist.

This tumour proved to be peculiar in appearance and at the time (*1913*) was variously designated neuroblastoma, endothelioma, neurocytoma, and a primary epithelial (?) tumour.

The patient made an astonishingly good recovery with unexpected improvement in vision and early restoration of movement in her paralyzed extremities. Subsequent letters state that by December, in spite of occasional convulsive seizures, she had improved so far as to be able to get up and down stairs unaided. After the expiration of six months she began to lose ground and on *April 16, 1914*, she was brought back to the hospital. There was obviously a huge recurrence regarded as inoperable, and she fortunately died in coma soon afterward.

The autopsy showed a massive growth not only with implantations of the tumour in the cicatrix of the former incision, but the cerebral ventricles and the cerebrospinal spaces of the base of the brain were inoculated everywhere with tumour cells.

This tumour, in its cytology and behaviour, differed from the more familiar medulloblastomas of the cerebellum only in its more prolonged survival-period which doubtless would have been still longer had it been customary in those days to subject the residual growth to radiation. An example of a so-classified "cerebral medulloblastoma" whose life history and behaviour in no way supports this histological diagnosis is as follows:

A married woman, 50 years of age (Surgical No. 14889), began having convulsive attacks in *1913*. These were generalized seizures with loss of consciousness, but in *1921* they began to show Jacksonian features with antecedent numbness and twitching in the left face, lip and hand associated with marked aphasia. The patient was left-handed and came of a left-handed family. Physical examination showed left astereognosis with increased reflexes and considerable aphasia and apraxia. At operation on *July 26, 1921*, a huge, postero-central tumour was brought to view and its principal mass was dislodged and removed.

The growth showed an alveolar structure with an abundance both of glia and nerve fibres. It was diagnosed at the time by Prof. S. B. Wolbach as "neuro-neuroglioma," in other words a glioma containing neural elements.

The patient was given X-ray treatments and did extremely well during the

next four years in spite of periodical epileptiform seizures. She reëntered the hospital in 1925 because of an increasing recent disability of the left hand with a return of her aphasia from which she had completely recovered. There was no increase of intracranial tension, the old temporal bone-defect being collapsed.

At a secondary operation, *November 19, 1925*, a small cystic area was found surrounded by a firm whitish tissue mass which was looked upon as a gliosis due to the radiation. A section of this tissue was excised and proved to be a neoplasm of the same type as before. It was then called a neuroblastoma, but this classification was changed a year later to medulloblastoma. She survived until *September 11, 1926*, the duration of life from the onset of symptoms having been 13 years.

What this case-history serves to emphasize is that an histogenetic classification which fails to take into account the differing behaviour of tumours, however similar their cellular composition may appear to be, can be highly misleading. On the basis of what is known of the cerebellar medulloblastomas, the surgeon would be led to regard the cerebral tumours with a similar cellular composition as equally hopeless. The same principle should be applied to them that guides us in the surgical treatment of cerebral gliomas of other and less favourable sorts: namely, as radical an extirpation as possible supplemented by suction and electrosurgical scalloping.

Statistics.—Two of the 18 cerebral "medulloblastomas" were not operated upon. On the remaining 16 there were 26 operations with 3 deaths, giving an 18.8 per cent case-mortality and an 11.5 per cent operative mortality. During the past three-year period 3 additional tumours of this type have been operated upon with no fatalities.

The combined figures for the cerebral and cerebellar lesions are of little significance because of the difference in the behaviour of the tumours in the two situations. For completeness only, it may be said that 80 of the 86 cases were operated upon 125 times with 28 deaths, giving a 35.0 per cent case- and a 22.4 per cent operative mortality. The 18 cases operated upon 22 times during the past three years with 5 fatalities give a present-day 27.7 per cent case- and a 22.7 per cent operative mortality for the so-called medulloblastomas regardless of situation.

These three major groups of the gliomas so far considered represent about 80 per cent (539 out of 687) of all the classified gliomas. The remaining 20 per cent are consequently tumours less likely to be encountered and are of surgical importance merely in that most of them stand in their degree of malignancy somewhere between the glioblastomas and the astrocytomas. Being, for the most part also, tumours of the cerebral hemispheres in adults, the desirability of learning to distinguish them from their more malignant relatives by their gross features at operation can be readily appreciated.

THE ASTROBLASTOMAS

These tumours, 35 in number, are highly interesting from an histological and no less so from a neurosurgical standpoint. With our better understanding of their life history and favourable prognosis they will soon come to be recognizable at the primary operation and be attacked with greater courage than heretofore. They are composed predominantly of elements which, as the name astroblastoma implies, are the precursors of astrocytes, and for the most part are tumours of the cerebral hemispheres of adults. Without microscopic study they are likely to be surgically mistaken for protoplasmic astrocytomas or even for glioblastomas which are found in corresponding situations. When encountered at a primary operation they are apt to be partly cystic in which respect they resemble the astrocytomas; but as time passes, they tend to become massive, semi-enucleable lesions often of huge size.

Bailey and Bucy,[28] in a recent description of twenty-five of these tumours from the writer's collection, have called particular attention to their characteristic histological architecture which in typical cases is unmistakable, but unfortunately the same assurance of type does not as yet pertain to their appearance at operation. Many of the tumours were originally classified with the multiform glioblastomas but their unexpected longevity which far exceeds that of the glioblastomas finally led to a restudy of the original specimens with disclosure of their real identity.

The unusual number of reoperations for certain "glioblastomas" in the series indicated that some of them possessed a lower degree of malignancy than others, and this fact of itself was enough to show that they were tumours with an altogether different cytology. One of the cases originally diagnosed as a glioblastoma had between 1920 and 1926 five successive operations for recurrences. Another case between 1923 and 1927 had four operations for recurrences before death, and there are patients still living six and seven years after a single operation—periods altogether too long for a glioblastoma.

As an example the following case may be cited. It shows the huge size they may attain, and how, with our present imperfect understanding of their clinical behaviour and unfamiliarity with their appearance at operation, they may even be mistaken for a meningioma.

A paper maker, 35 years of age (Surgical No. 37939), entered the hospital *January 2, 1931*, with a history of Jacksonian seizures in the left arm and neck for two years; of weakness and numbness of the left side of the body for three months; and of headaches for only five weeks. He was found to have a unilateral choked disc of 5 diopters on the right side accompanied by an exophthalmos, and an essentially normal fundus on the left. A left sided hemiparesis with complete astereognosis and increased reflexes pointed to a tumour of the right parietal lobe, and since the X-ray showed thinning of the skull in this region associated with unusual vascularity of the scalp, the finding of a meningioma was anticipated.

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[28] Bailey, P., and Bucy, P. C. Astroblastomas of the brain. Acta Psychiat. et Neurol., 1930, v, 439-461.

At operation on *January 10*, a large right osteoplastic flap was turned down disclosing an extremely dense dura. On reflecting this upward, a tumour was brought to view still partly concealed so that a large amount of additional bone had to be rongeured away posteriorly to uncover it (Fig. 30). The growth lay adjacent to the longitudinal sinus from which, like the ordinary meningioma it received an abundant vascular supply. It was electrically circumscribed and gradually began to extrude itself with considerable loss of blood. It was finally

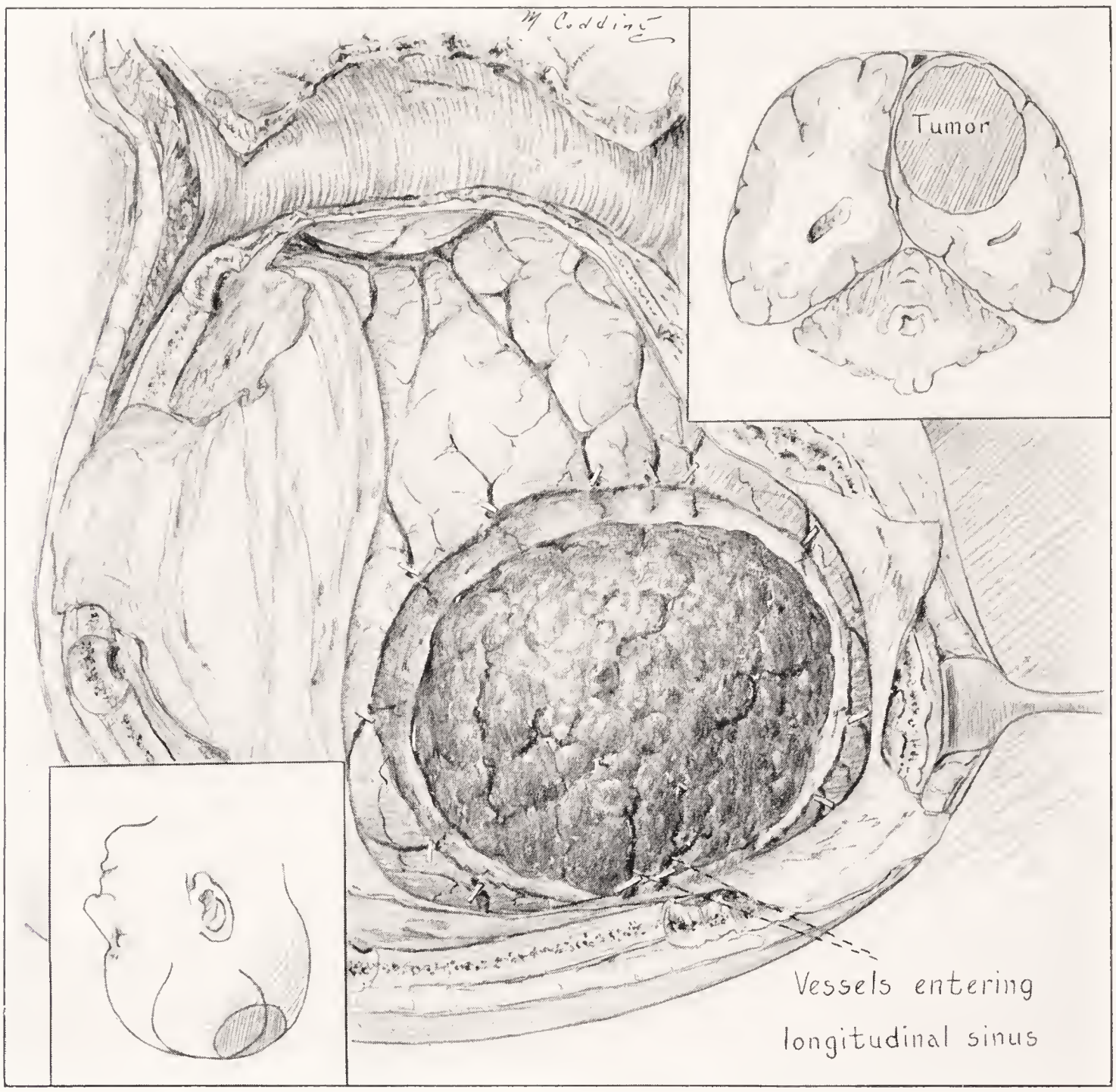


FIG. 30. Showing the operative field with necessary posterior enlargement of bone defect to expose unexpectedly large astroblastoma (*cf.* Fig. 31). Tumour partly exposed after cortical "uncapping."

enucleated, apparently in its entirety, though it was partly fragmented in the process. It was necessary to give the patient three blood transfusions in the course of the operation.

The tumour (Fig. 31) was a large growth weighing 220 grams. Immediate examination in the fresh during the course of the operation had made clear that it was not a meningioma but an astroblastoma, typical astroblasts with a single long heavy process being disclosed (Fig. 32). Subsequent studies of the tumour

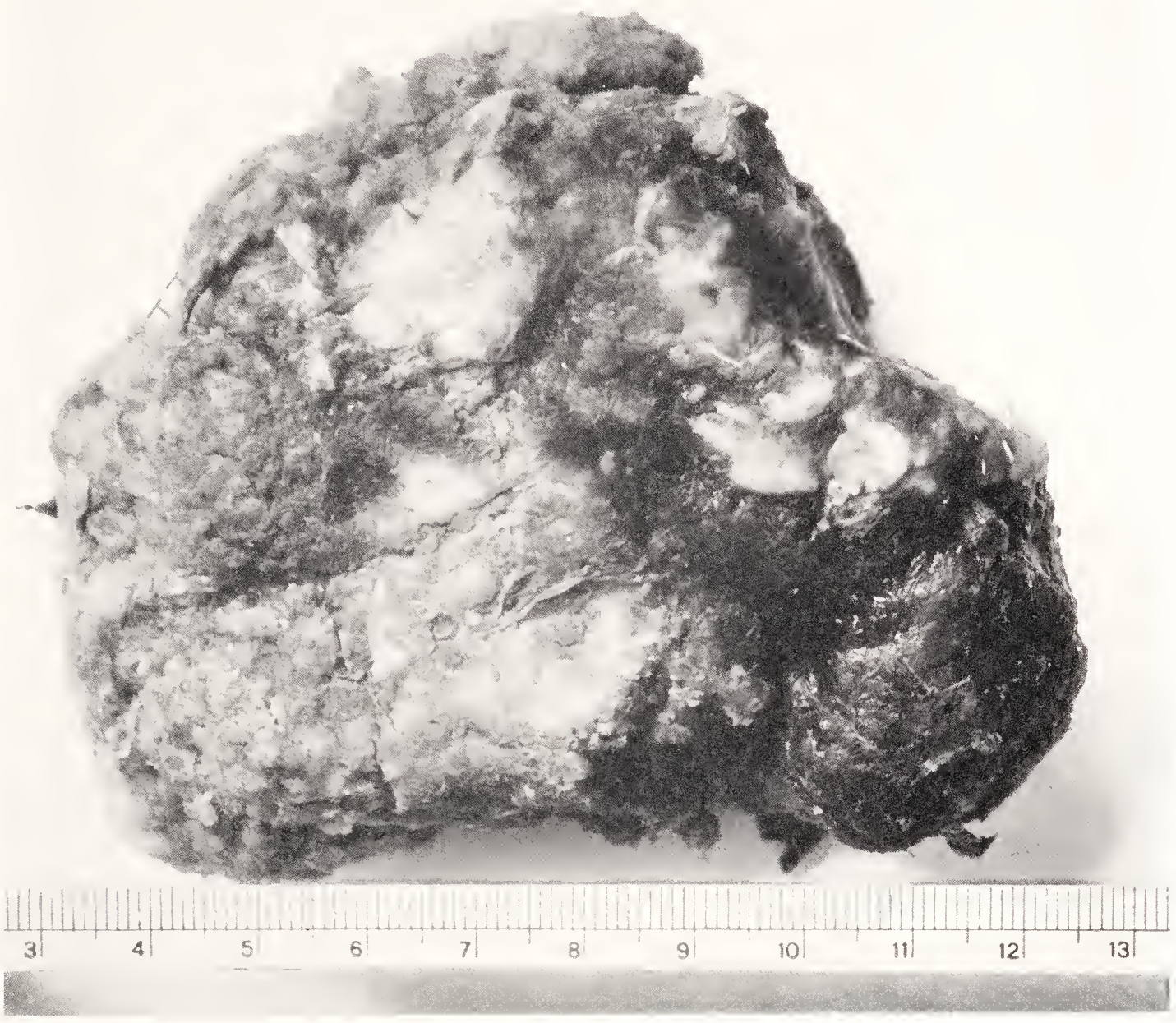


FIG. 31. The 220-gram astroblastoma as removed at operation.

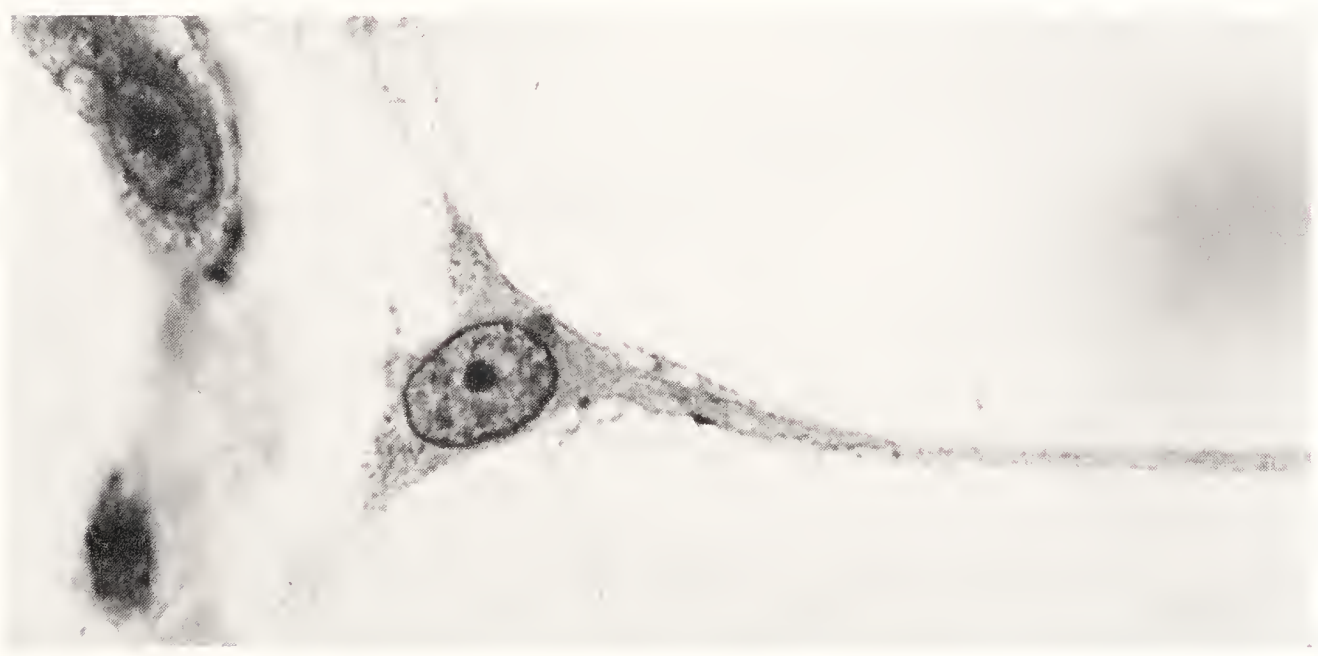


FIG. 32. Supravital preparation of tumour in Fig. 31. Typical isolated astroblast with single long process to blood-vessel (not shown) and two stubby processes.

after fixation showed the characteristic architecture of an astroblastoma as described by Bailey and Bucy (Fig. 33).

On *January 11*, the patient was found to have passed a quiet night and to be in good condition. He was taking nourishment well and moving his left leg though the arm was paretic. At the dressing the following day 100 cc. of blood-stained cerebrospinal fluid was removed from under the flap with a brain needle and some of the sutures were cut. The wound was in perfect condition and there was no tension.

It was not thought necessary for the patient to have a special attendant but his bed in the ward was put where he could be easily overseen by the night nurse. During her momentary absence he got out of bed by himself, apparently

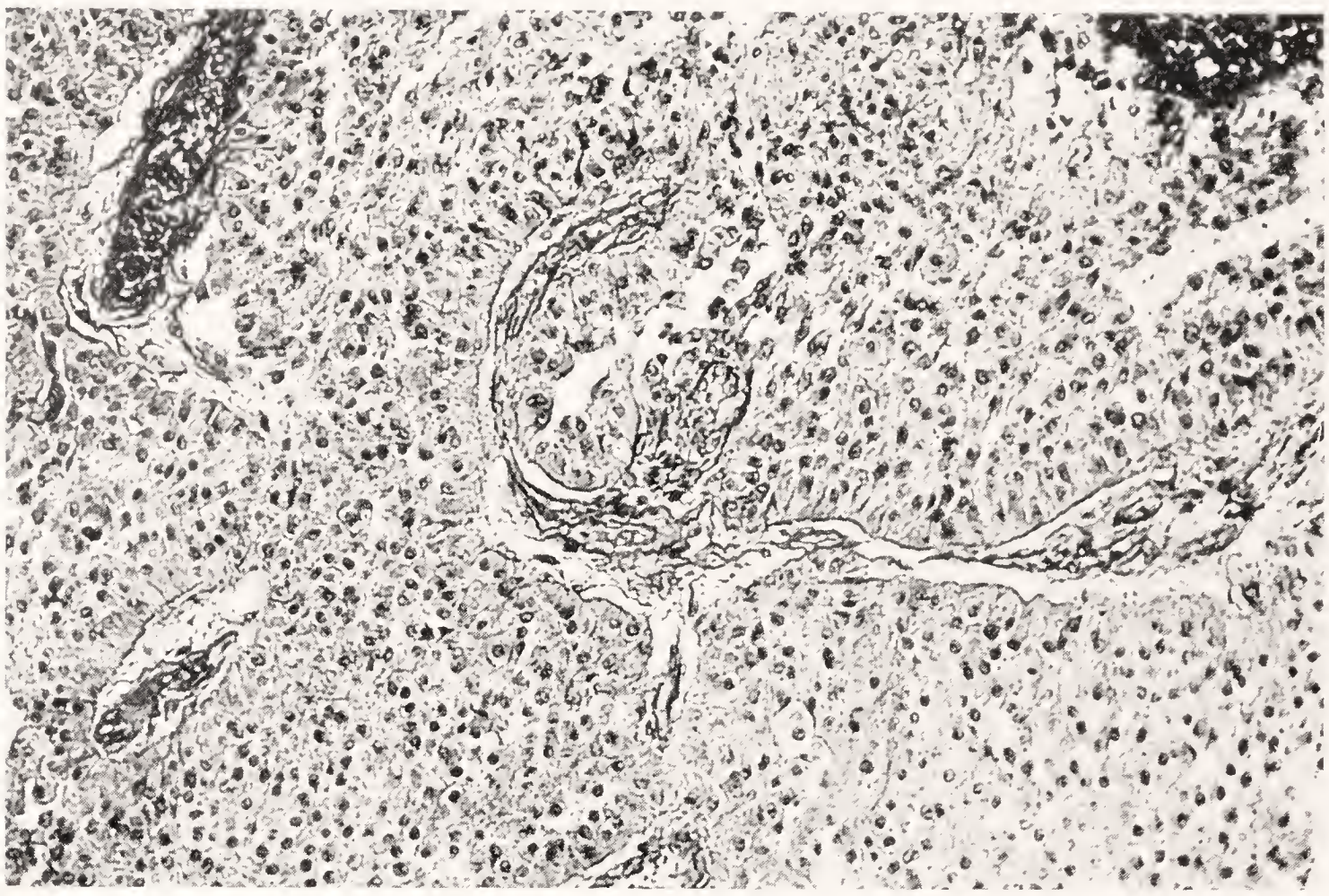


FIG. 33. Fixed-tissue section of tumour (phosphotungstic acid hematoxylin, ×150) showing characteristic perivascular arrangement of astroblasts with hyalinization of vessels to whose walls cell prolongations are attached (*cf.* Fig. 32).

to go to the adjacent toilet, and was found on the floor unconscious with his dressing heavily blood-stained.

So soon as possible, preparations were made for an immediate examination of the wound. On removing the dressing it was found that the entire flap had been torn loose exposing a fungating protrusion of brain with blood welling up from the depth. There was very little that could be done. He died shortly after the wound was reclosed. The autopsy showed a long fracture running across the base of the skull with extensive basilar haemorrhage.

Statistics.—Four of the 35 tumours in the collection so far identified as astroblastomas were secured at autopsy without preceding operation. In the 31 remaining cases 58 operations have been performed with 10 fatalities giving a 32.2 per cent case-mortality and a 17.2 per cent oper-

ative mortality. As further knowledge of these tumours is acquired these discreditable percentages will doubtless come to be greatly improved. It is encouraging that in the last three-year period 7 patients with 10 operations and the single fatality described above give for the present day a 14.3 per cent case-mortality and a 10 per cent operative mortality.

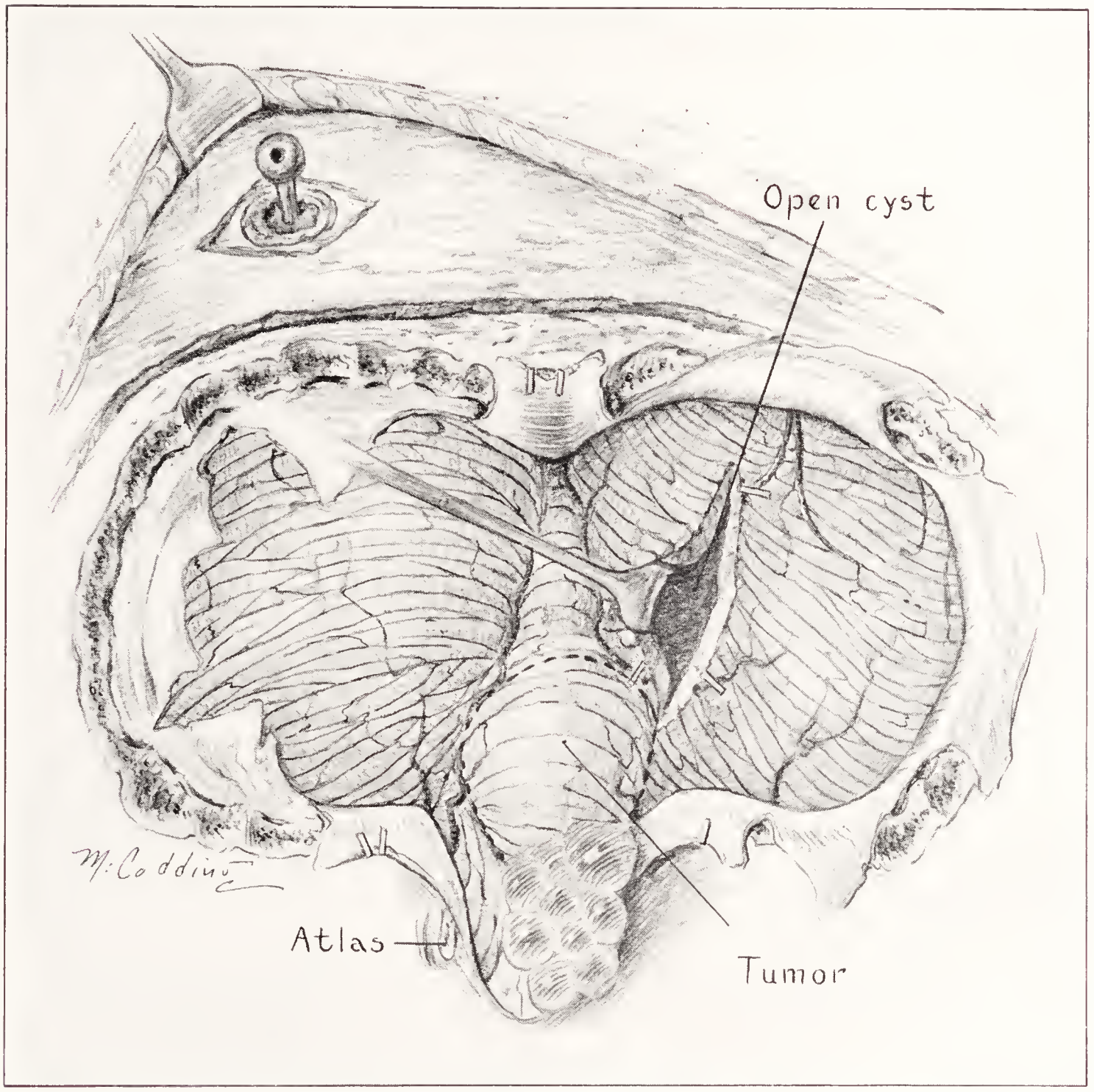
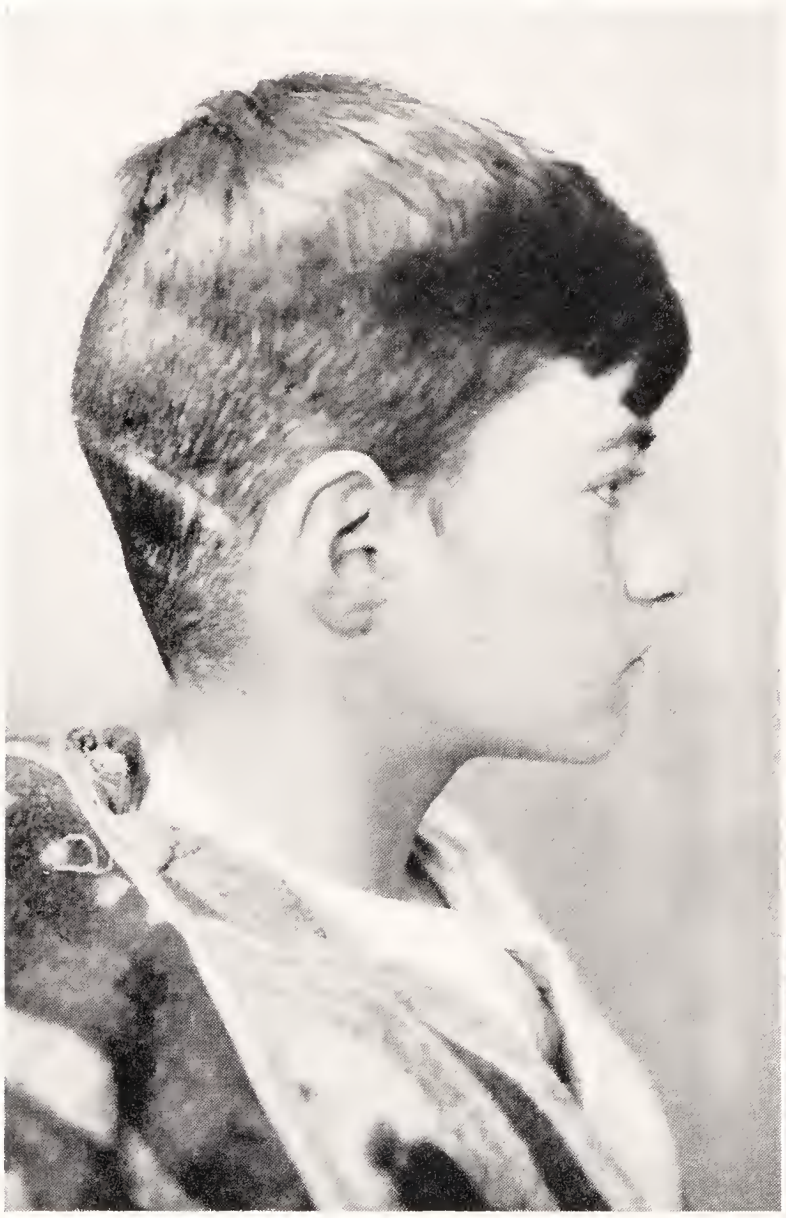


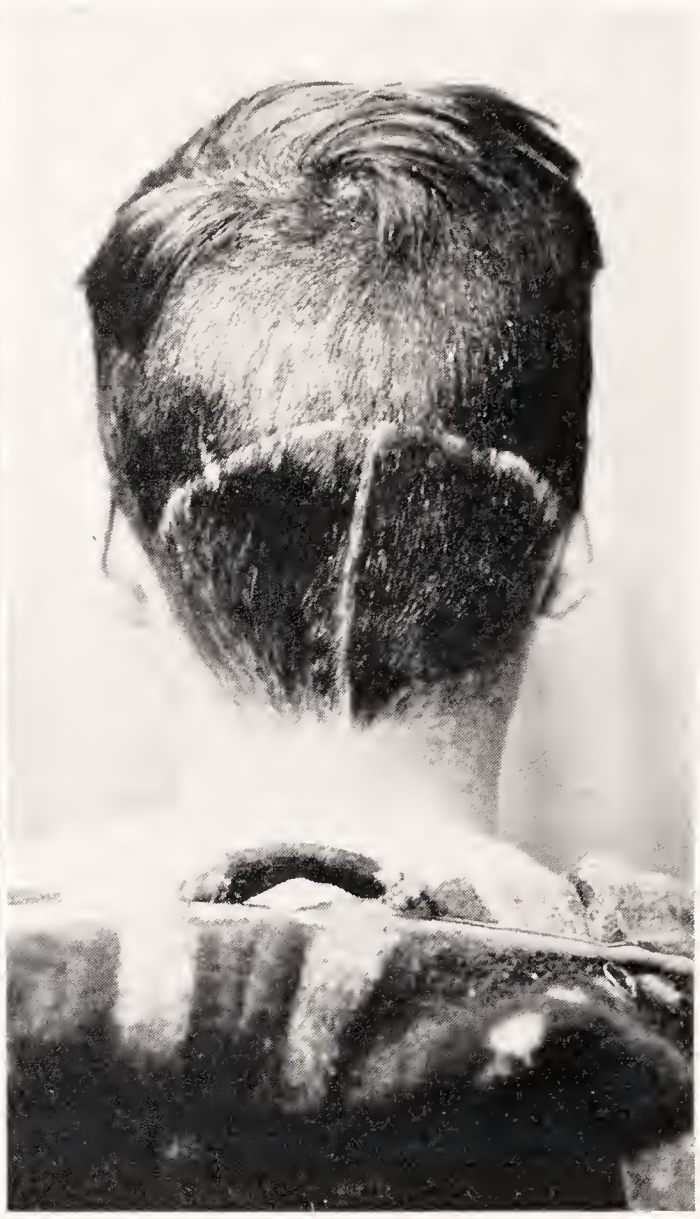
FIG. 34. Operative sketch showing appearance of posterior cerebellum on exposure of tumour which proved to be a spongioblastoma polare.

SPONGIOBLASTOMA POLARE

Tumours of this histological type are composed predominantly of spongioblasts (*cf.* Fig. 38), the former attempt to subdivide them into bipolar and unipolar types being now regarded as an unnecessary refinement. The life history of the 32 examples in the series has recently been

fully presented by Bailey and Eisenhardt.[29] They are relatively benign, slowly growing lesions and were it not that they occur less often in the hemispheres than in relatively inaccessible parts of the brain from which their removal would be hazardous, they would be regarded as highly favourable for surgical attack. An example of a tumour favourably situated for removal and which without differential study of its cytology would have been looked upon as a cystic astrocytoma is as follows:





FIGS. 35, 36. Patient on discharge after operation 11 years ago for what was then called "cystic glioma" (spongioblastoma polare).

A boy 11 years of age (Surgical No. 12153) was admitted *March 29, 1920,* with a history of having been struck by an automobile on the head 18 months previously without subsequent symptoms. For eight weeks before admission he had been having matutinal vomiting supposedly gastric in origin. This was soon followed by the rapid development of an unmistakable cerebellar syndrome with nystagmus, ataxia, instability, a bilateral choked disc and roentgenological evidence of hydrocephalus.

At operation on *April 8, 1920,* a peculiar looking subpial tumour was disclosed in the lower vermis (Fig. 34), with so great a degree of herniation into the spinal canal of a multicystic tonsil, a laminectomy of the atlas was necessary for

[29] Bailey, P., and Eisenhardt, L. Spongioblastomas of the brain. J. Comparative Neurol. (in press).

its exposure. Instead of the primary median incision of the vermis which would have been favoured to-day, a lateral incision of the hemisphere was made opening into a large cyst. The easily accessible tumour nodule was then readily removed, together with the involved tonsil. The patient made a prompt recovery from the operation (Figs. 35, 36) with early subsidence of all symptoms and now, e l e v e n y e a r s l a t e r , remains in perfect health.

The growth, originally classified as a "cystic glioma" was recognized as a unipolar spongioblastoma of pure type when we began to subject the gliomas to differential study.

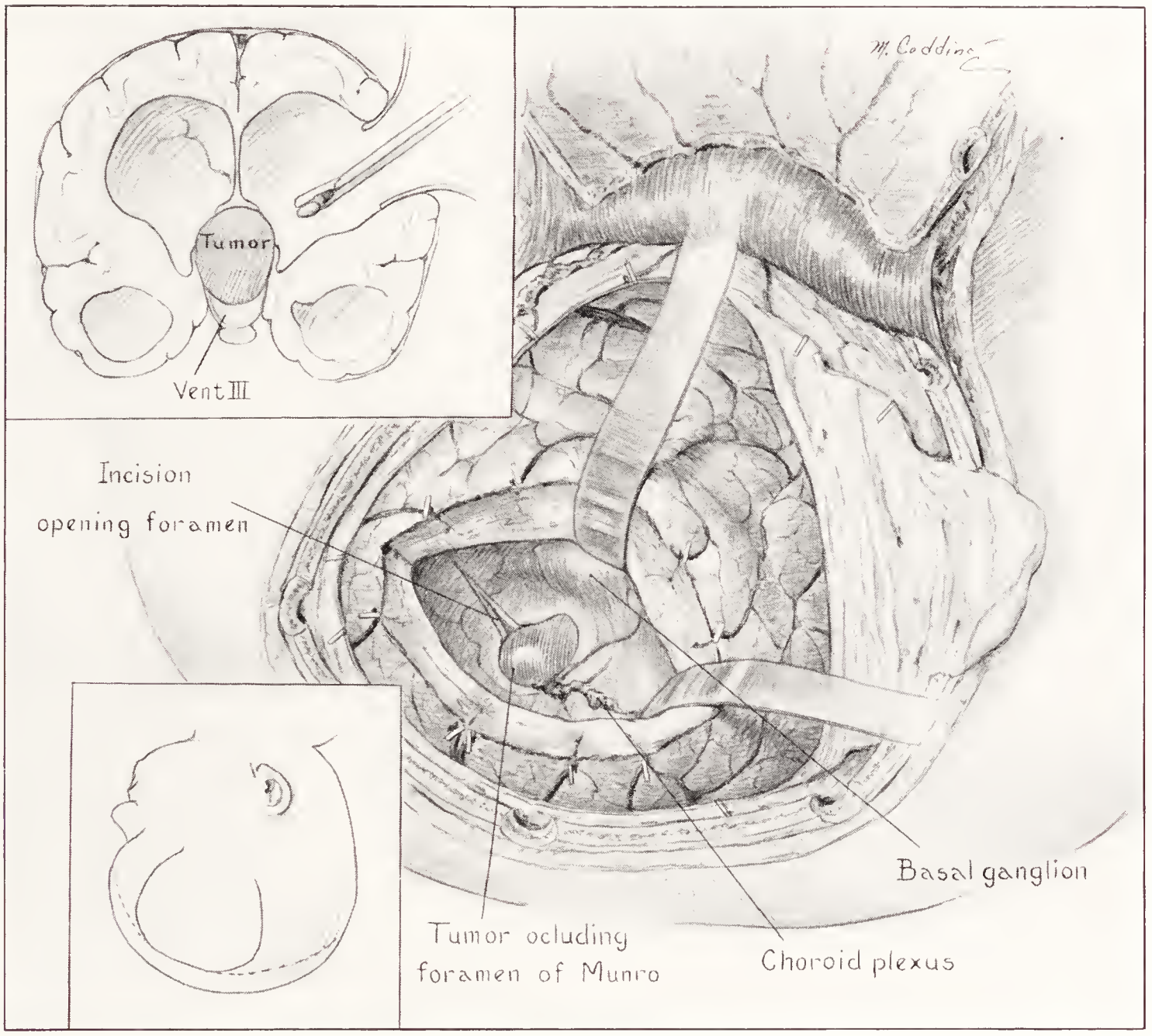


FIG. 37. Operative sketches showing method of transcortico-ventricular exposure of tumour in third ventricle (spongioblastoma polare).

A more recent case in which the diagnosis was made by supravital methods at the moment of its operative exposure is as follows:

Nancy H. (Surgical No. 32289), an uncoöperative and irritable child 3 years of age, was first brought to the hospital *September 21, 1928,* with the history of tumour symptoms of a year's duration. There was hydrocephalus, choked disc and beginning secondary optic atrophy, ataxia, instability, hypotonicity, increased deep reflexes with bilateral Babinski toe response, tilting of the head and suboccipital tenderness but no nystagmus.

Though there had been no history of vomiting, the diagnosis of probable midline cerebellar tumour was finally made. At a suboccipital exploration on *October 20* no tumour was found. A subsequent ventriculogram on *November 1* disclosed a suspicious filling defect of the third ventricle, presumably from tumour, for which she was given X-ray treatments and discharged.

During the next two years the child was frequently seen and examined, the symptoms remaining essentially unaltered. Always well nourished, there was a growing tendency to adiposity and possibly polyuria but the latter could not be definitely determined.

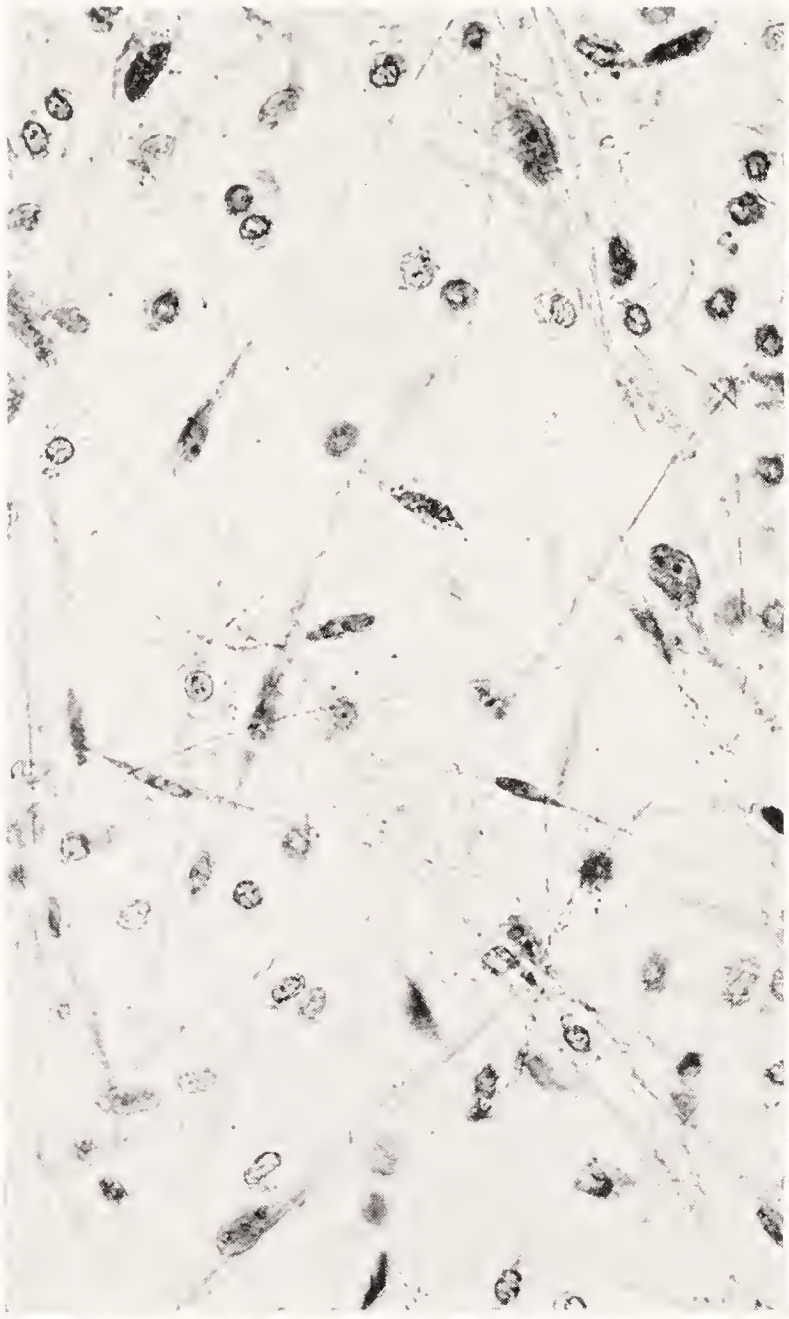


FIG. 38. Supravital preparation (×300) of case reported (No. 32289), showing typical cross hatching of bipolar spongioblasts having appearance of pure culture of the same. For comparison with Fig. 39.

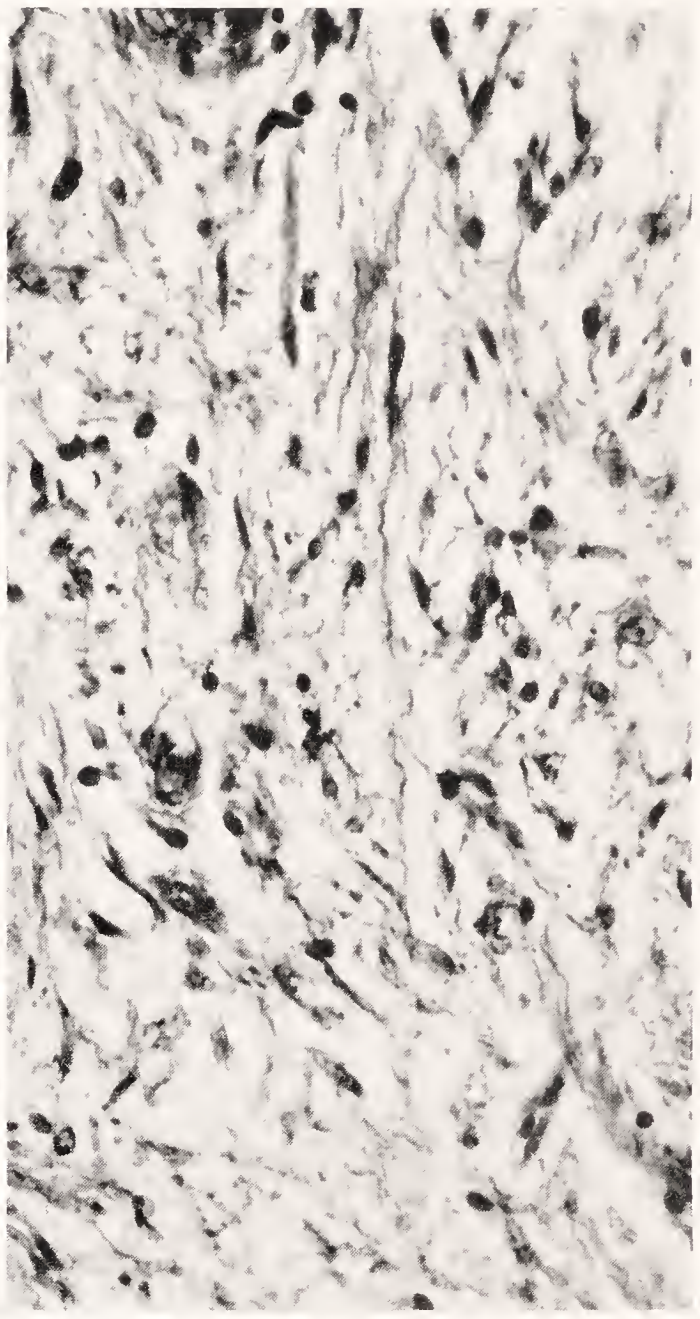


FIG. 39. Zenker-fixed preparation (methylene blue eosin, ×300) of the same specimen. A single spongioblast with long dependent crinkled process can be detected vertically placed in the centre of the field.

Early in *1931*, the ventriculograms were repeated and the anterior part of the third ventricle was found to be unmistakably occupied by a cyst or tumour. From lack of coöperation it was very difficult to examine the fundus oculi but fleeting glimpses of the nerve head revealed no abnormality and there was certainly no undue pallor. No indication of hemianopsia was made out on rough tests, so that the chiasm presumably was not involved.

On *March 24, 1931*, under novocaine-avertin-ether, a large anteriorly placed bone-flap was turned down exposing the right hemisphere. An electro-surgical incision was made through the thin frontal cortex opening the dilated ventricle which was sucked dry. In the base of the ventricle the greatly enlarged foramen of Monro was easily identified (Fig. 37) with the choroid plexus emerging from it. The foramen was occluded by greyish tumour, pressure upon which allowed fluid to escape.

The better to expose the growth an incision was made enlarging the foramen and a fragment of the tumour was taken for supravital examination, an immediate histological diagnosis of bipolar spongioblastoma (Figs. 38, 39) being returned by Dr. Eisenhardt. Much of the soft avascular growth was then sucked out, fluid pouring from the opposite ventricle through the unblocked foramen on that side. The huge cavities were filled with physiological salt solution before the flap was replaced and closed.

The child made an excellent recovery with a remarkable transformation in her previously ill tempered and uncoöperative personality. She was discharged *April 14* and remains well to date (*July 1, 1931*), about four years since the onset of symptoms.

The scarcity of tumours of this cellular type, the disparity of age of the patients and the variable situation of the lesions are such that a preoperative diagnosis could scarcely be made; nor could one presume as yet definitely to distinguish one of these lesions from other gliomas by its gross appearance alone. The age of the patients has varied from 3 years to 64 years; 11 tumours have arisen from the optic chiasm and third ventricle, 5 from the pons, 7 from the cerebellum, and 9 from the cerebral hemispheres and basal ganglia. The tumours tend therefore to lie along the lower axis of the brain and they consequently are more likely to be verified at autopsy than at operation, the situation of the lesion in many instances preventing its removal. Operations consequently may often be merely palliative as in the second of the two cases given in illustration.

Statistics.—All but one of the 32 patients were operated upon with 36 operations and 8 postoperative fatalities, giving a 25.8 per cent case-mortality and a 22.2 per cent operative mortality. In the last three-year period, there have been 7 patients with 12 operations and a single fatality, giving for the polar spongioblastomas a 14.3 per cent case- and an 8.3 per cent operative mortality.

OLIGODENDROGLIOMA

These slowly growing tumours occur almost exclusively in the cerebral hemispheres of adults, and as they are particularly prone to show spotty shadows of calcification on the X-ray films, the correct preoperative diagnosis is often made. So far, 27 examples have been identified, several of them, because of their highly cellular character, having originally been mistaken for cerebral medulloblastomas. There still remain a considerable number of relatively benign border-line tumours which though otherwise classified at present [*cf.* page 37] may well enough prove to be closely allied

types when we come to learn more of the life history of these highly interesting neoplasms.

Percival Bailey was the first clearly to distinguish them from other gliomas. Two years ago he with Bucy,[30] chiefly from a histopathological standpoint, made a report upon the 13 examples in the Brigham collection which up to that time had been identified; and the fact that 14 others have since been added to the list shows that they are more common than we formerly supposed.

When fixed, stained and sectioned by ordinary methods, the lesions have a characteristic and often unmistakable appearance, the compact mass of small cells with scanty clear cytoplasm having, as Bailey points out, some resemblance to the section of a woody plant. The unshrunken cells in fresh tissue preparations, on the other hand, show a fairly abundant cytoplasm (*cf.* Fig. 45) with no evidence of the cell processes or tails which are supposed to characterize oligodendroglial cells. What is more, contrary to our earlier impression, mitoses are usually to be found in these tumours, and we now know that their prognosis is much less favourable than their tendency to undergo calcification formerly led us to expect.

In reviewing the hospital histories, it is highly interesting to see how many shifts in diagnosis have been made, not only in the case of the older tumours in the collection, but even in the more recent examples, which, at various hands, have been diagnosed medulloblastoma, neuroblastoma, spongioblastoma, etc. But the general tendency is for more rather than for fewer tumours to gravitate into the oligo-glioma group.

A man, 48 years of age (Surgical No. 33706), was admitted to the hospital on *April 9, 1929*, with a letter from his doctor stating that for five years he had been endeavouring to convince himself that the patient had a tumour, but not until two weeks previously had he decided that the symptoms could only thus be accounted for. A summary of the positive findings which led to a preoperative diagnosis of oligodendroglioma is as follows:

Subjective

1. Attacks, left-sided, mild, for 16 years; more severe, 9 months.
2. Aphasia, slight, transient, appreciated for the past 5 years.
3. Weakness of the right leg, transient, and facial weakness, right side, of sudden onset and 6 weeks' duration, *August 1928*.
4. Recent diplopia, recurrent, transient, 2 months.
5. Right homonymous hemianopsia disclosed 2 weeks ago, possibly present for 3 years.
6. Mental inertia for past 7 months.
7. Olfactory hallucinations for past month.

Objective

1. Complete left-sided anosmia.
2. Right homonymous hemianopsia.
3. Chronic choked discs of 1 to 2 D. with evident secondary atrophy.
4. Large irregular mass of calcification in left occipital lobe (*cf.* Fig. 40).

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[30] Bailey, P., and Bucy, P. C. Oligodendrogliomas of the brain. J. Path. & Bacterial., 1929, XXXII, 735–751.

On *April 20, 1929*, under local anaesthesia, a left occipital osteoplastic flap was turned down disclosing an unexpectedly tense dura so that an immediate subtemporal decompression was made. On reflecting the dura the parietal convolutions showed evident flattening and an electro-surgical curvilinear incision was made through the cortex exposing at a depth of possibly 2 cm. a soft semi-encapsulated tumour. Fragments were removed for immediate examination in the fresh and showed a highly cellular growth whose cells, some of which were

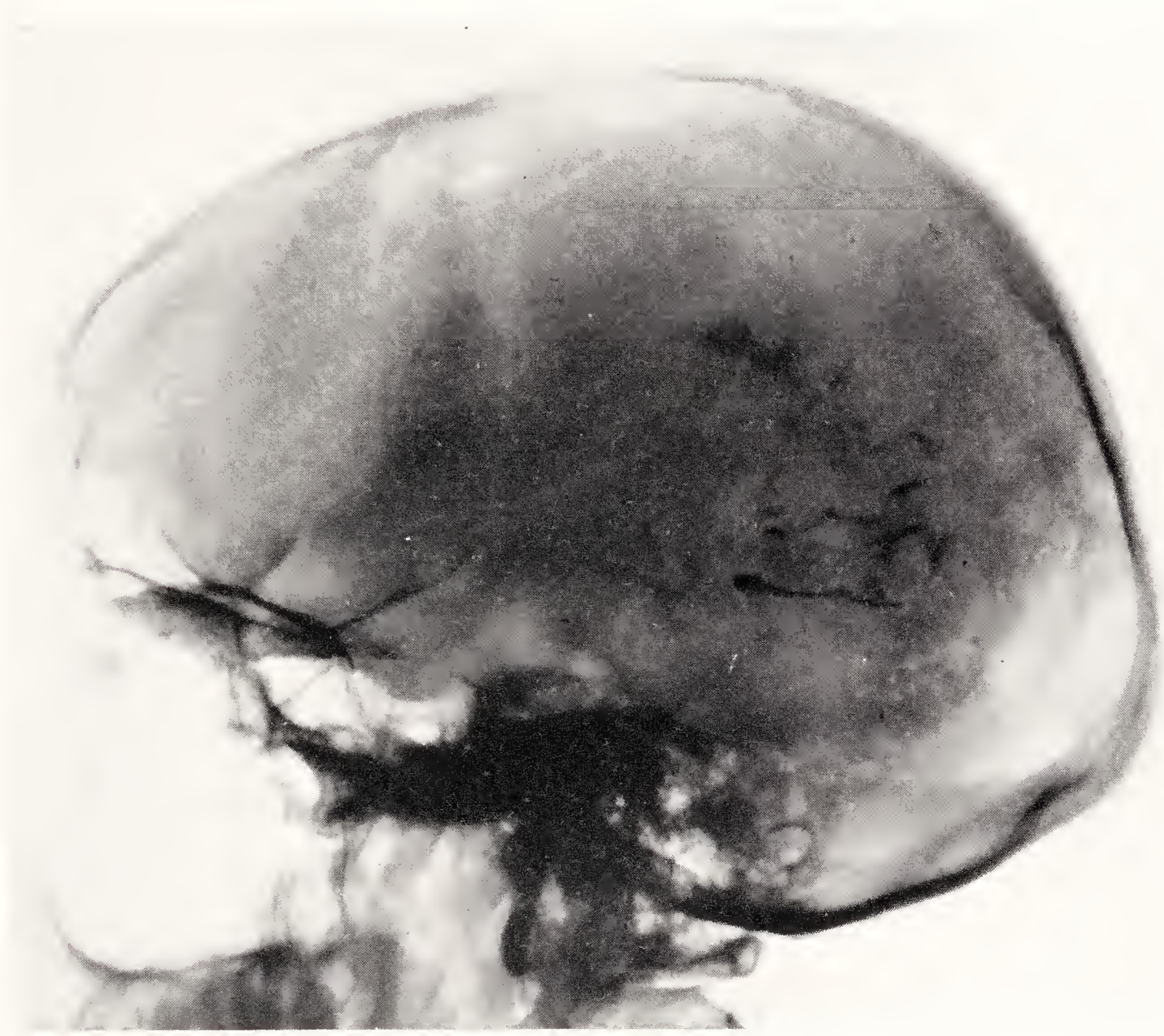

FIG. 40. X-ray showing spotty calcification in parieto-occipital region leading to preoperative diagnosis of oligodendroglioma.

multinucleated, suggested medulloblasts; but in view of the calcification and long history of the case were taken to be oligodendroglia cells.

Chiefly by suction a mass of tumour as large as a tennis ball was removed with free exposure of the falx (Fig. 41). Bleeding was checked by implantation of pledgets wet in Zenker's fluid, by clips, and by electro-coagulation. The flap was replaced and closed as usual without drainage.

From this long 4-hour operation the patient made a prompt recovery, but to our dismay postoperative cranial X-rays showed that there was still a large amount of calcification extending from the site of operation forward into the temporal region. Hence, on *May 11, 1929*, a secondary operation was per-

formed. By this time the incision in the cortex had become firmly reunited and the reëxposure of the field was difficult owing to its vascularity. Nevertheless the growth was pursued to a depth of fully 9 cm. down into the temporal region where some bleeding was finally set up so that the operation was concluded.

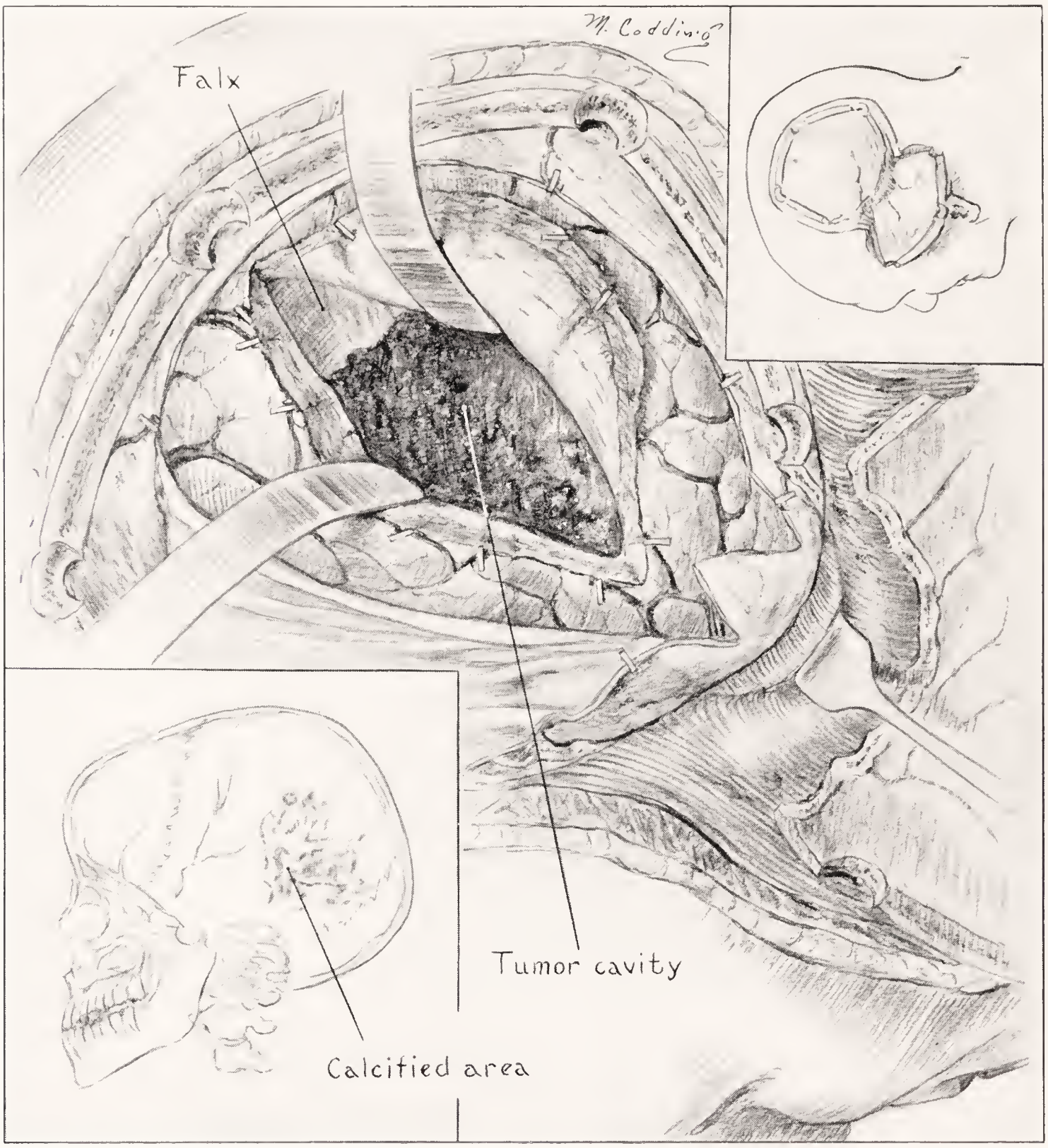

FIG. 41. Operative sketch showing situation of operation and cavity left after excavation of large oligodendroglioma exposing falx.

The bone-flap at this session was sacrificed. Fixed tissue preparations of the tumour of both sessions showed a typical oligodendroglioma with mitoses (Figs. 42, 43).

From this second operation he again made a prompt recovery and subsequent roentgenograms showed that the larger part of the deep calcified mass had been removed. He was discharged on *May 24* in excellent condition, almost all of his symptoms except the persistent right homonymous hemianopsia hav-

ing subsided. He was given a series of X-ray treatments before his discharge. He soon resumed his occupation, and though symptomatic recurrence may be expected he has remained essentially symptom-free now for two years though there is an unmistakable increase in the residual calcification shown by recent X-ray films.

In this case seven years have elapsed from the symptomatic onset, but this is by no means exceptional. Another patient in the series began having focal epilepsy with aphasia in 1912; was first operated upon in 1916, again in 1925, and survived until 1929, the whole story covering a period of 16 years. Though these tumours are more common in adults,

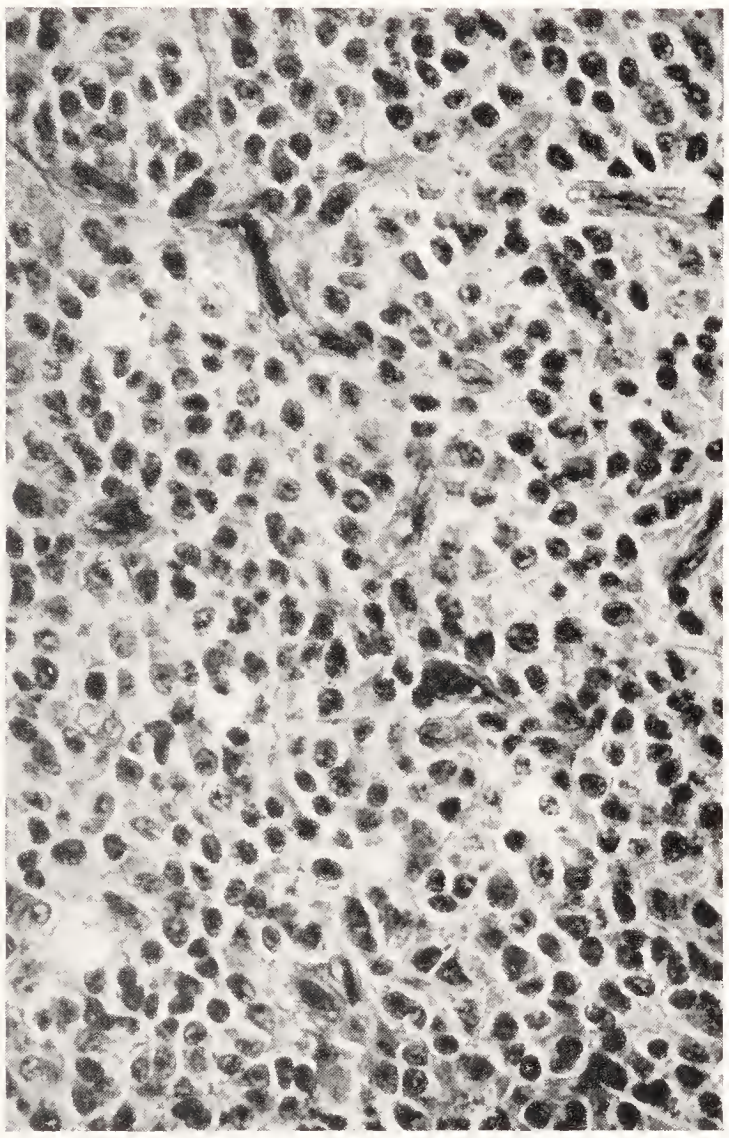

FIG. 42. Fixed-tissue preparation (×300) of oligodendroglioma.

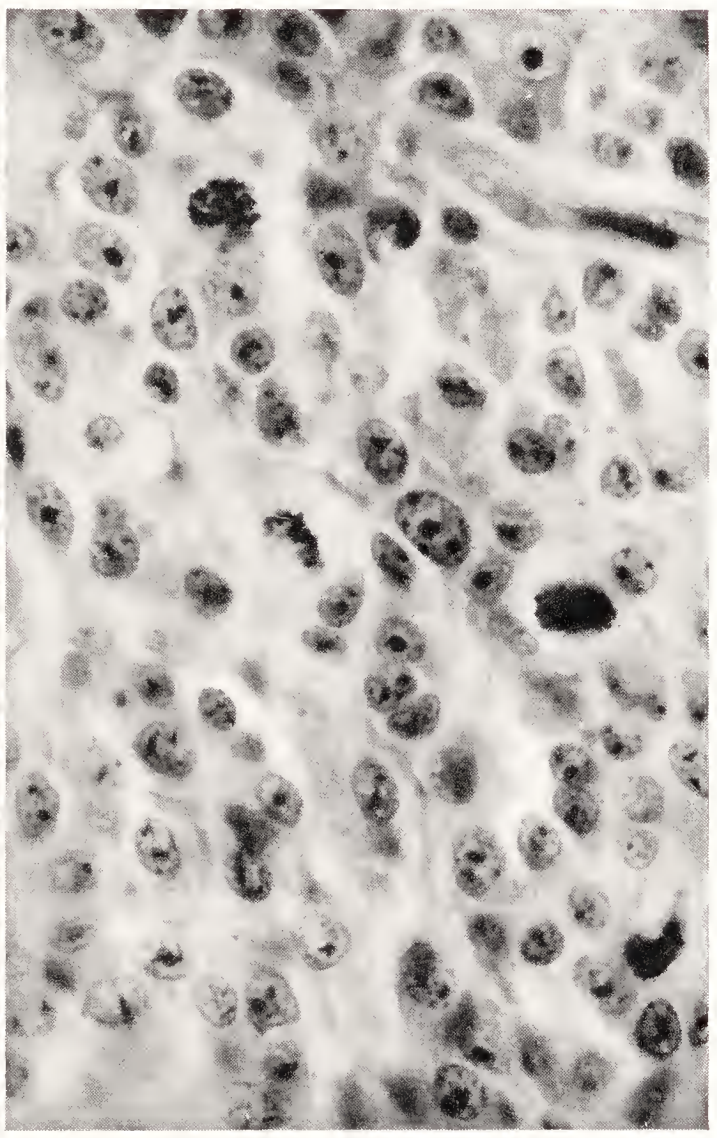

FIG. 43. The same (×600) showing mitotic figures. Mallory's stain.

they are not restricted to them. The picture of a large occipital oligodendroglioma in a child of 5 years of age was given (page 143) in our glioma monograph.[11] We have recently had an example in a lad of 12 in whose case there had been left-sided focal epilepsy with progressive palsy during the preceding twelve months; at the operation, August 12, 1929, a large cyst was found with a small partly calcified mural nodule which was cleanly removed but which showed abundant mitoses. Recurrence of symptoms nine months later necessitated a second operation at which time a solid tumour the size of the original cyst was enucleated.

It has been suggested by Penfield that the tumours might properly be

divided into *oligodendroblastomas* in which mitoses abound, and into less rapidly growing *oligodendrocytomas* in which polar spongioblasts and occasional astrocytes are often demonstrable. Fortunately most of the tumours, being of the latter type, are favourable in that they ordinarily do not greatly increase intracranial tension and therefore often fail to show a choked disc (*cf.* W. P. Van Wagenen, *loc. cit.*[5]) they tend rather to replace brain than to crowd it aside and to cause oedema. Consequently after a radical operation recurrences of large size may slowly reappear,

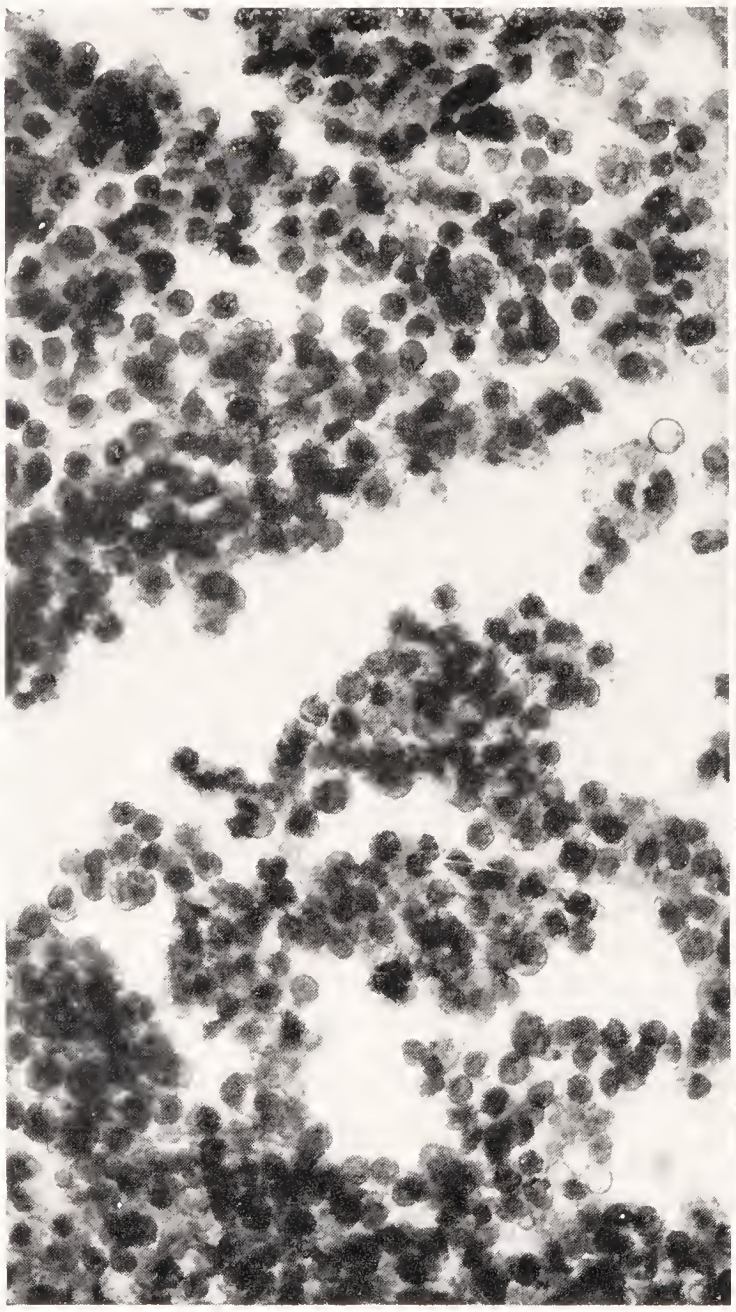

FIG. 44. Showing supravital preparation of fresh cells from tumour (×300). (*cf.* Fig. 42).

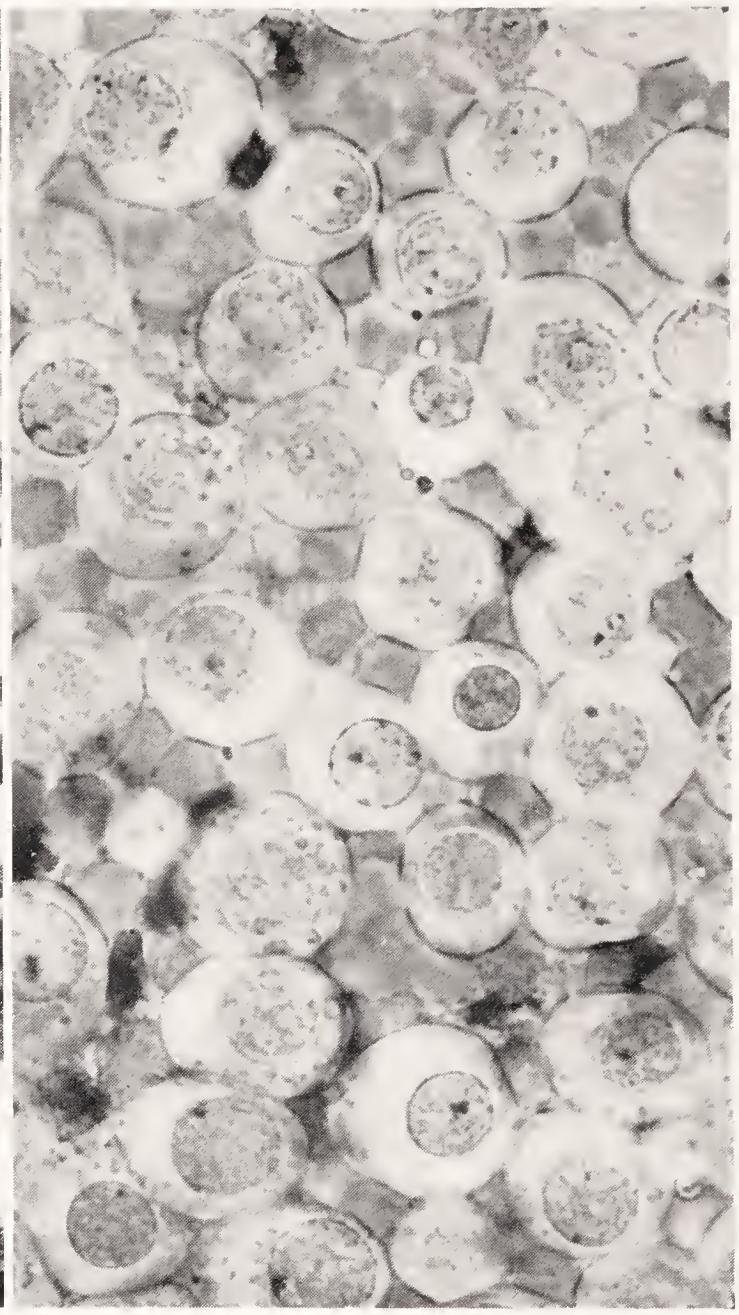

FIG. 45. The same (×850) showing clearly marked cell boundaries of oligo cells by this method.

roentgenologically betrayed by spreading calcification, without there being any protrusion at the site of a decompression.

One would suppose that the more actively growing oligodendroblastomas would be beneficially affected by radiation, but I do not feel that we have conclusive evidence that they are favourably influenced in the slightest. The only example in the series that was consistently radiated showed a massive recurrence three years after a primary frontal lobectomy at which time the radical extirpation was repeated with prompt and

complete temporary symptomatic recovery, but a recurrence with fatality took place within a year.

Several years ago Professor Forsell of Stockholm, after watching the incomplete extirpation of a malignant glioma, suggested that we try the effect of temporarily implanting in the cavity a ball of proper size containing a core of radium. Acting on this suggestion we have occasionally buried such a radium "bomb"* for varying periods of time after massive

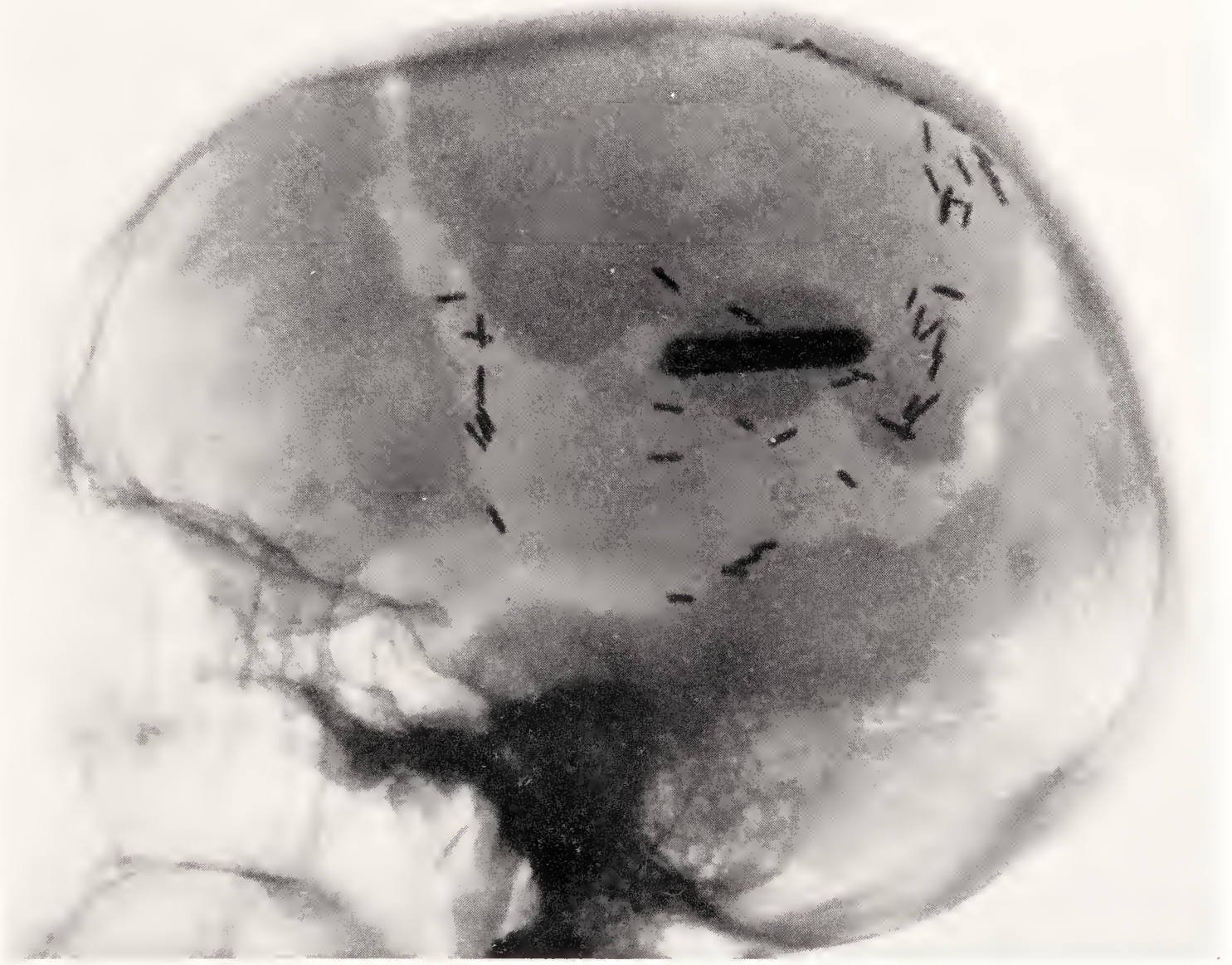

FIG. 46. Showing position of radium bomb in cavity of large incompletely excavated oligo-glioma.

extirpations particularly of glioblastomas. This same procedure was employed without appreciable benefit on an oligo-glioma in the following instance:

A man 40 years of age (Surgical No. 35810) for a year had been conscious of unusual fatiguability associated with headaches and occasional attacks of

* The type of "bomb" we have used is made up of a central core of radium needles enclosed in a rubber sponge and wrapped in thin rubber tissue, the size corresponding approximately to the size of the cavity left by the removal of a malignant tumour. The dosage we have customarily employed, viz., four needles each containing $12\frac{1}{2}$ mgm. of radium screened with a one millimetre silver jacket and buried for four days represents approximately 5,000 mgm. hours. The distant effect is shown by the almost instantaneous fogging of an X-ray film held against the distant side of the head and also by the subsequent complete depilation of the scalp.

numbness in his left hand and face. He was found to have a choked disc of 4 diopters, a left lower facial weakness of central type, and some astereognosis in the left hand. Cranial roentgenograms showed a streaky mass of calcification deep in the right parieto-occipital region measuring 10 cm. in its antero-posterior diameter, evidently an oligodendroglioma.

At operation on *February 27, 1930,* a soft, partly necrotic easily suckable tumour containing gritty calcification was exposed by a transcortical incision and in large part sucked out. Supravital examination showed (Figs. 44, 45) a mass of round cells with clear protoplasm and sharply cut nuclei, numerous mitoses being present. He made an excellent recovery from this operation but subsequent roentgenograms showed that only the posterior half of the large calcified mass had been removed; and as his subtemporal decompression remained tense and the choked disc did not subside, it was deemed necessary to do something more.

Consequently on *March 14* the original flap was reflected and an additional large mass of tumour which had meanwhile tended to push its way to the surface was easily removed by suction. In the open cavity the "bomb" was implanted and left *in situ* (Fig. 46) for four days when the flap was again elevated and it was removed. The dosage in this case amounted to 4,600 milligram hours and the subsequent depilation of the scalp was complete.

There was perfect wound healing and at the time of his discharge on *April 17,* the decompression was flat, the choked discs had subsided and the astereognosis had practically disappeared.

He returned to the hospital six months later to have the condition checked up. It was quite apparent from his symptoms that the residual tumour was expanding and additional widespread calcification was roentgenologically apparent. A series of X-ray treatments were then instituted but they have failed in any appreciable way to alter the clinical picture though at the present writing, 15 months later, it shows no material change.

Statistics.—Of the 27 verified oligodendrogliomas, 26 were operated upon 46 times with 4 postoperative fatalities, giving a 15.4 per cent case-mortality and an 8.7 per cent operative mortality. The figures for the July 1, 1928–July 1, 1931 period comprise 8 new cases, operated upon 13 times with no postoperative fatalities.

THE EPENDYMOMAS

These tumours were among the first of the gliomas in the series to be histologically differentiated. In Dr. Bailey's two early papers on this subject[31,32] which were chiefly devoted to a histological description of the 14 lesions then identified, they were divided into ependymoblastomas and ependymomas—a refinement we no longer regard as essential.

The ependymomas, now only 25 in all, make a scant 3 per cent of the gliomas as a whole. Apart from the fact that they are comparatively be-

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[31] A study of tumors arising from ependymal cells. Arch. Neurol. & Psychiat., 1924, XI, 1–27.

[32] Quelques nouvelles observations de tumeurs épendymaires. Ann. d'Anat. path. méd.-chir., 1925, X, 481–512.

nign lesions, which naturally affects their prognosis and treatment, they do not represent a highly important surgical problem. Since those of the cerebellum differ considerably in their gross features and behaviour from those in the cerebrum, like the astrocytomas they are therefore given separate consideration.

The cerebellar lesions.—Nineteen of the 25 ependymomas have been disclosed in the course of explorations for median cerebellar tumours. In no instance has a preoperative pathological diagnosis been made. They are usually non-cystic lesions partly exposed to view through the transparent arachnoid of the posterior cistern, and they tend more than do the astrocytomas and medulloblastomas of this region to send a long projection of tumour into the spinal canal. Hence a laminectomy of atlas, and not infrequently of axis as well, is necessary for their proper exposure.

The tumours are firm, and are evidently enucleable. The temptation consequently is strong to attempt their total removal, but owing to their dangerous position this has usually led to a fatality. Cases which have been simply decompressed have survived for many years. Like some other comparatively benign gliomas the tumours tend to show calcification even when in the posterior fossa, where spotty calcification is less easily picked up on X-ray films than when it occurs in the cerebrum.

In the German edition of our glioma monograph[33] (page 116) there is a picture of a large calcified ependymoma in a child of nine who had died following operation. The lesion had been clinically diagnosed as a probable calcifying tuberculoma in view of the appearances on the X-ray films. A very similar case in an adult with a more fortunate outcome is as follows:

The patient, a clerk, 41 years of age (Surgical No. 33003), had been admitted to the medical wards of the hospital on *December 22, 1928*, with a history of headaches, vomiting, unsteadiness, some instability, and a supposedly Parkinsonian appearance. A cerebellar tumour was considered possible, but it was thought that an alcoholic toxaemia or a post-encephalitic syndrome was a more probable diagnosis.

He was seen for a neurosurgical consultation on *January 3* and it was thought that he unquestionably had a cerebellar tumour in spite of his normal eyegrounds. This opinion was based on his eight months' history of occipital headaches with vomiting, his typical cerebellar instability and ataxia, hyperactive reflexes and increased tension of the spinal fluid. There was marked mental confusion, urinary incontinence, unequal pupils, and absence of nystagmus; so the diagnosis at best was uncertain.

To settle the matter, recourse was had to ventriculography which showed greatly dilated ventricles whereupon an immediate cerebellar exploration under novocaine was made. So soon as the posterior cisternal arachnoid was opened, a tongue of tumour was disclosed projecting downward into the spinal canal from the region of the calamus, and for its proper exposure it was necessary to laminectomize the atlas as shown in the accompanying sketches (Fig. 47). The

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[33] Bailey and Cushing. Die Gewebs-Verschiedenheit der Hirngliome und ihre Bedeutung für die Prognose. Jena, Gustav Fischer, 1930.

vermis was then vertically incised bringing to view a massive central tumour. The intraspinal projection was removed without difficulty, and the larger mass was extirpated by a combination of suction and scalloping, a small slip of tumour being left behind where it was apparently adherent to the floor of the IVth ventricle headward to the calamus. Histologically the growth proved to be a typical ependymoma (Figs. 48, 49).

Following this operation there was evidence of nuclear palsies involving the Vth, VIth and VIIth nerves on the right side but these disturbances rapidly

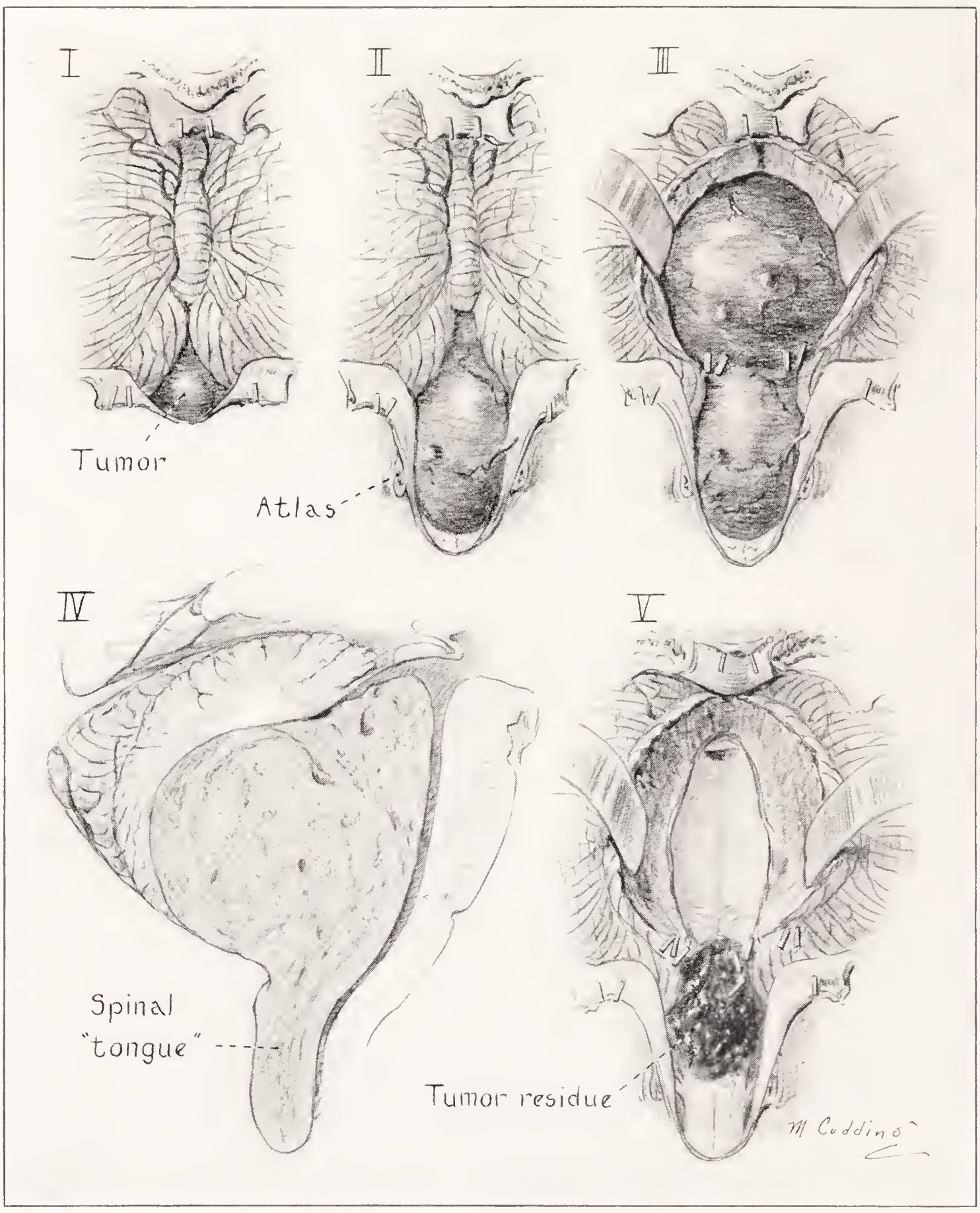

FIG. 47. Showing (I, II and III) the median cerebellar ependymoma as exposed in different stages of operation. Note (V) the residual fragment left *in situ*,

subsided. Several daily lumbar punctures were performed after the operation, large amounts of fluid being withdrawn at each session. Convalescence was somewhat stormy owing to persistent hiccoughs, but he finally began to improve, his mental condition cleared, he ceased to be incontinent, and on *February 24, 1929*, when he was discharged he was in excellent condition (Fig. 50) with but slight residual ataxia.

When he last reported on *August 11, 1931*, he stated that he had not missed a day's work since *April 1929*.

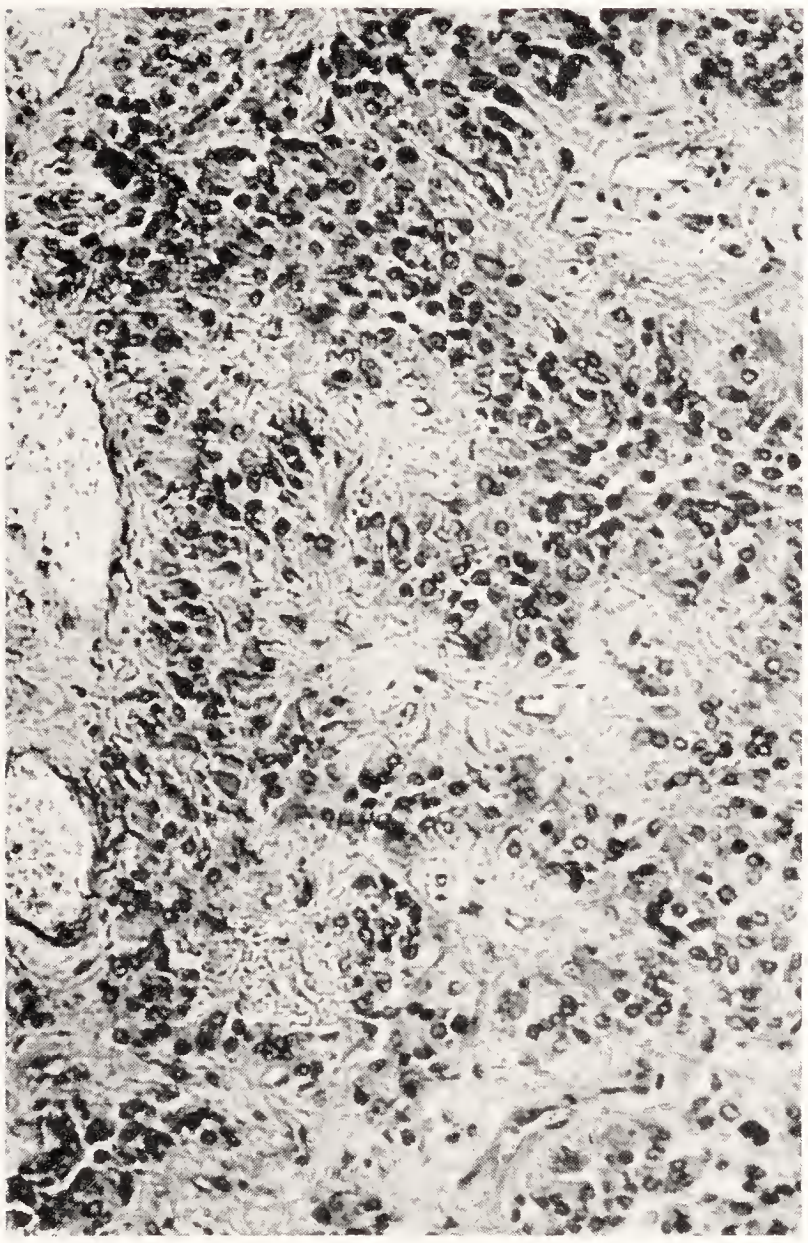

FIG. 48. Perivascular arrangement of cells and pseudo-rosettes of typical ependymoma cited in text (hematoxylin and eosin, ×150).

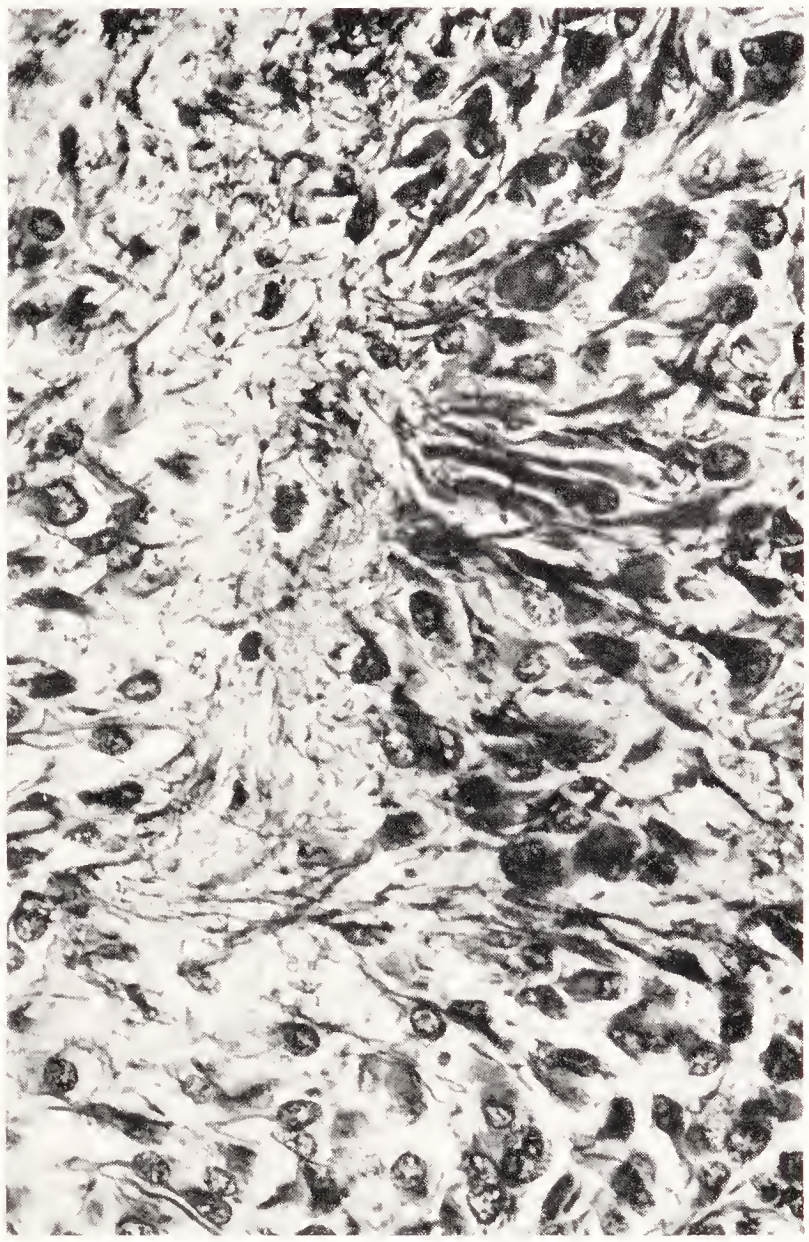

FIG. 49. Higher magnification of same tumour showing attachment of ependymal spongioblasts to vessel walls (phosphotungstic acid hematoxylin, ×300).

Statistics.—Sixteen of the 19 cerebellar cases have been operated upon 19 times with 5 fatalities, giving a 31.3 per cent case-mortality and a 26.3 per cent operative mortality.

The cerebral ependymomas.—These, according to our present list, are only 6 in number. What was true of the cerebral medulloblastomas and oligo-gliomas is equally true of the cerebral ependymomas, most of them having from time to time been variously diagnosed. An example of a huge recurrent tumour once thought to be an ependymoblastoma has

been given in illustration of an unclassifiable glioma [*cf.* page 13]. The cerebral lesions are more likely than the cerebellar ones to become cystic and most of them have given roentgenological evidences of calcification. They supposedly should take their origin from the ventricular ependyma but certain of them like the one to be mentioned below have failed to show any such connection even though from its histological appearances the growth is definitely recorded as an ependymoma.

A woman, 21 years of age (Surgical No. 23217), was admitted on *February 14, 1925*, with a five months' history of subjective right homonymous hemianopsia associated with severe headaches. These symptoms were looked upon

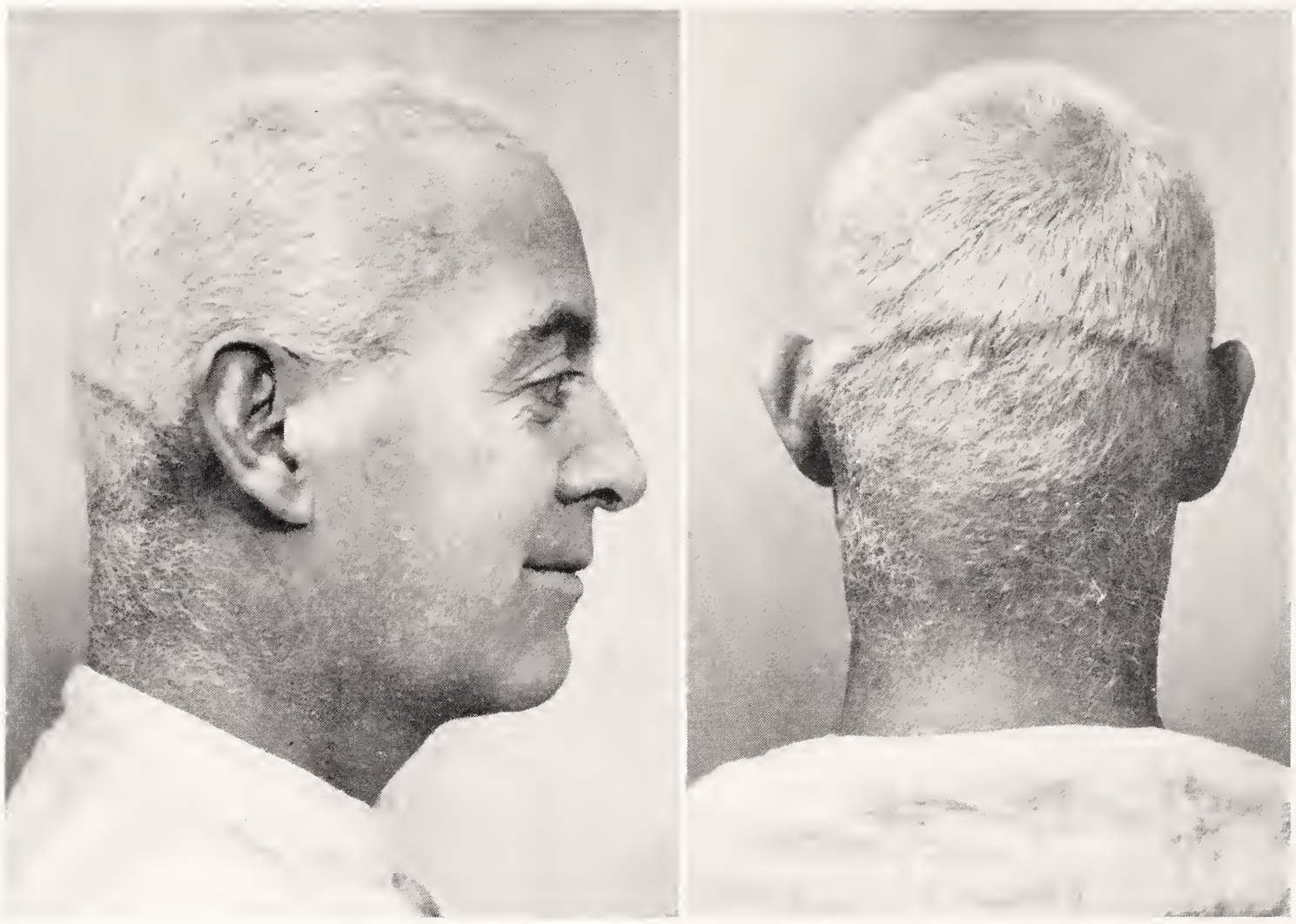

FIG. 50. Patient on discharge after removal of large median cerebellar ependymoma with intraspinal projection (*cf.* Fig. 47).

as functional as they occurred a few days before her wedding. Her hospital admission was precipitated by the occurrence of a series of generalized convulsions.

She was found to have an acute bilateral choked disc, an incomplete right homonymous hemianopsia, and an apparent, slight word blindness. The cranial roentgenograms disclosed a calcified tumour in the occipital region just to the left of the midline; and at operation on *February 21* an occipital flap was turned down disclosing a large cyst adjacent to the falx within which was a readily enucleable tumour nodule weighing 54 grams.

The growth proved to be composed of closely packed cells of variable size, most of which had tapering processes. Many of the cells were accompanied by deeply staining fibrils and their general architecture (Fig. 51) led to the diagno-

sis of ependymoma, which still stands on the records though I personally have grave misgivings on this score in view of the distance of the lesion from the ventricles.

The patient made a good recovery from this operation, was subsequently married and has raised a family of children. Her anniversary letter bearing the date of *February 5, 1931*, states that she continues to enjoy perfect health, six years having passed since her operation.

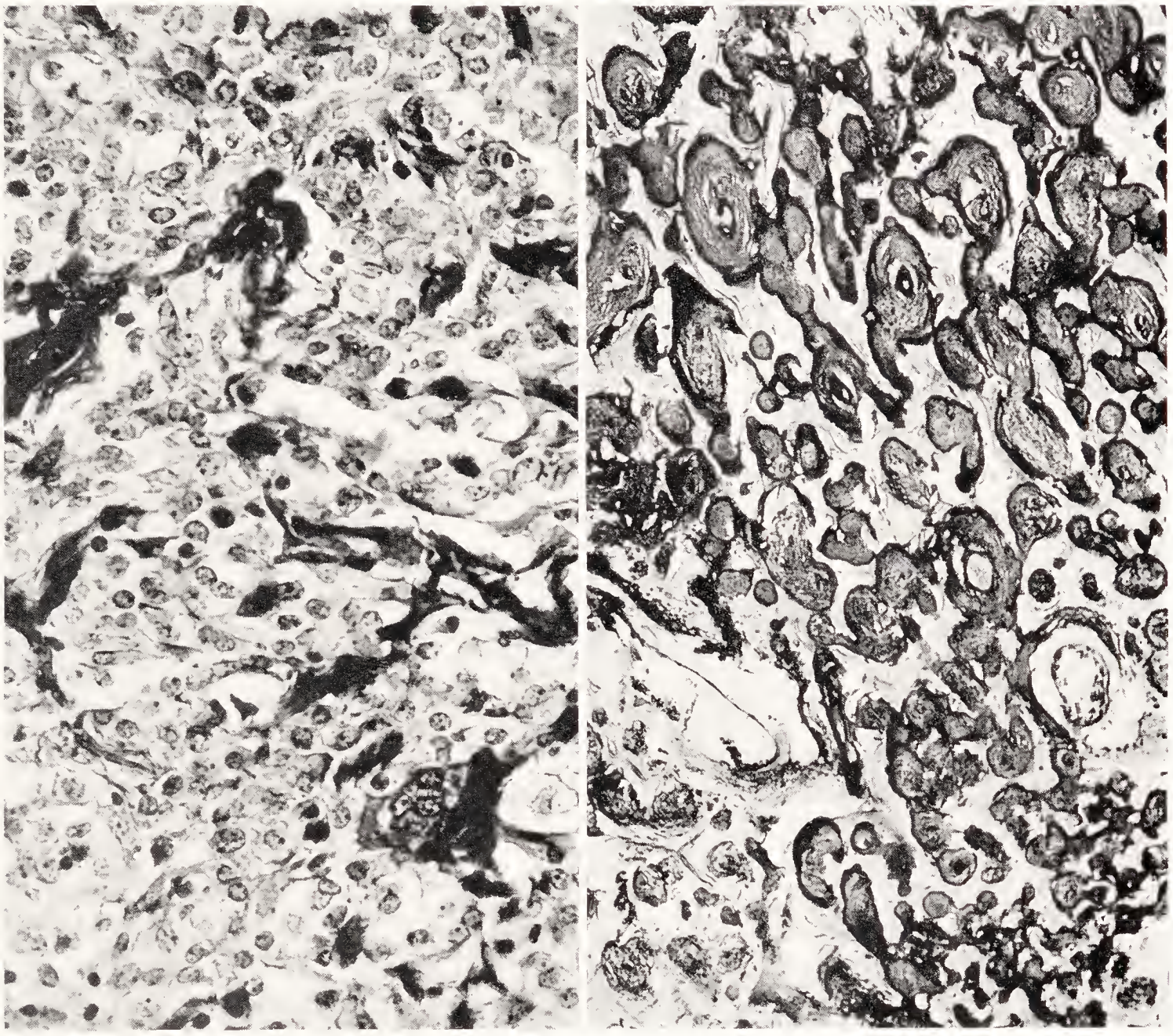

FIG. 51. Photomicrographs of "ependymoma" mentioned in text, to show: (a) the character of the cells and their relation to stroma (phosphotungstic acid hematoxylin, ×300); and (b) area of densely hyalinated tissue with obliteration of blood vessels (hematoxylin and eosin, ×80).

From this account it will be seen that some of these cerebral tumours are far less malignant than others, and this may justify Dr. Bailey's early inclination upon histological grounds to subdivide them into ependymoblastomas and ependymomas.

Statistics.—In such a small group of tumours so variable in their situation and physical characters, mortality figures do not mean much. The high mortality percentages have less to do with the cellular composition of the lesions than with the huge size some of them may attain and with the dangerous situation occupied by those in the posterior fossa.

All 6 of the cerebral cases have been operated upon, with 11 operations and 2 fatalities, giving a 33.3 per cent case- and an 18.2 per cent operative mortality. In the combined cerebral and cerebellar series, therefore as a whole, 22 cases have been operated upon 30 times with 7 deaths, giving a 31.8 per cent case- and a 23.3 per cent operative mortality. In the last three-year period, there has been a single death in 4 cases—a 25 per cent mortality, both case- and operative.

There remain three groups of tumours in our already considerably compressed list into which the gliomas formerly were subdivided: the pinealomas, the ganglioneuromas, and the neuroepitheliomas. None of these tumours will be ripe for sound surgical consideration until their life history has been worked out. Only of the foregoing seven larger groups can it be said that we are in a position to make a reasonably accurate guess at the type of tumour before operation. Before this is possible the following several stages must be gone through: (1) We begin first of all to localise tumours regardless of their type; (2) We then venture to expose and verify them by surgical measures; (3) When sufficient in number these regional tumours are then studied and their various histological types distinguished; (4) This accomplished, it becomes possible slowly to work out the life history of the several histological types; and when this is done, (5) We begin to venture upon preoperative *type* diagnoses as well as localising diagnoses. So long as verified tumours of a particular kind in a particular situation remain few in number, we must continue to deal with them purely from a regional standpoint rather than from the standpoint of their histopathology.

PINEALOMAS

Though these tumours have been made the subject of special study by Horrax and Bailey,[34,35] they are so few in number and so variable in their histological composition that their life history and the possible relation of any one type to the condition known as "pubertas praecox" is imperfectly understood. In his earlier grouping of the gliomas, Bailey drew a distinction between pinealomas and pineoblastomas, but some of the latter were so closely akin to the medulloblastomas both in their microscopic appearance and behaviour (e.g., in their tendency to seed themselves in the floor of the third ventricle), they subsequently were reallocated[32] with the cerebral medulloblastomas. This, I think, was an unwise move, for it merely adds further confusion to a group of tumours which, as we have seen, [*cf.* page 38] is already composed of lesions of widely differing history.

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[34] Tumors of the pineal body. Arch. Neurol. & Psychiat., 1925, XIII, 423–467. Also:

[35] Pineal pathology. Further studies. *Ibid.*, 1928, XIX, 394–413.

From a surgical standpoint it seems better therefore to let the term "pinealoma" for the time being represent an anatomical place-name rather than to have it connote any particular type of tumour. Were this principle adopted, it would mean drawing into this group the teratomas and ganglioneuromas of the pineal body which unfortunately are classified elsewhere. Until the surgical problem is solved, we cannot expect to secure a sufficient number of specimens to justify an attempt satisfactorily to classify them, much less to foretell before operation what will be found —a goal which some day in all probability will be attained. In other words, pineal tumours, like tumours of the third ventricle,[36] are still in the stage in which their symptomatic and localising features are of far greater importance from a neurosurgical point of view than their histological differentiation.

All of the pineal tumours in our verified series have been autopsy specimens, a goodly number of the patients having been subjected, in days gone by, to misdirected suboccipital explorations on the assumption that the clinical syndrome pointed to an intracerebellar tumour. And as a matter of fact, when one comes to review the photographs in the papers by Horrax and Bailey, it is surprising to see what a large percentage of the tumours extend backward so as to compress the anterior vermis or even to invade the IVth ventricle.

It is scarcely possible with definiteness to distinguish pineal tumours clinically from growths originating in adjacent structures like the corpora quadrigemina or pons;[37] and without ventriculography, which may show the filling defect of a tumour projecting forward into a distended IIIrd ventricle, one may often be doubtful as to the localising diagnosis. But even when a tumour is disclosed in this way, we can scarcely at the present day foretell its place of origin, much less its histological composition.

An illustration of one of the few tumours in the series, which has not heretofore been fully described, is shown in the accompanying figure (Fig. 52): The patient (Surgical No. 21567) was admitted to hospital in June 1924 in an advanced stage of intracranial tension with a clinical diagnosis which lay between a pineal tumour and a tumour of the corpus callosum. Death occurred shortly after ventriculograms were made, and they as a matter of fact failed clearly to show anything other than a marked hydrocephalus. Most of the tumours we have seen post mortem have been equally unfavourable for surgical intervention.

It has been our custom, when a tumour of the pineal region was suspected or has been demonstrated by ventriculography, to make a generous subtemporal decompression, should loss of vision be feared, in the hope of temporarily relieving the tension while the tumour is being subjected to active radio-therapeusis. This is of course a therapeutic shot in the

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[36] Fulton, J. F., and Bailey, P. Contribution to the study of tumors in the region of the third ventricle: their diagnosis and relation to pathological sleep. J. Nerv. & Ment. Dis., 1929, LXIX, 1–25, 145–164, 261–277.

[37] Horrax, G. Differential diagnosis of tumors primarily pineal and primarily pontile. Arch. Neurol. & Psychiat., 1927, XVII, 179–190.

dark so long as the tumour's precise histological type is unknown; but it may be condoned on the grounds that the pineoblastomas at least may be looked upon as tumours probably as susceptible to the effect of radiation as the cerebellar medulloblastomas. There have been no post operative fatalities in the 10 cases diagnosed as "pineal tumour unverified" and thus treated.

Personally I have never succeeded in exposing a pineal tumour sufficiently well to justify an attempt to remove it. Encouraging reports of

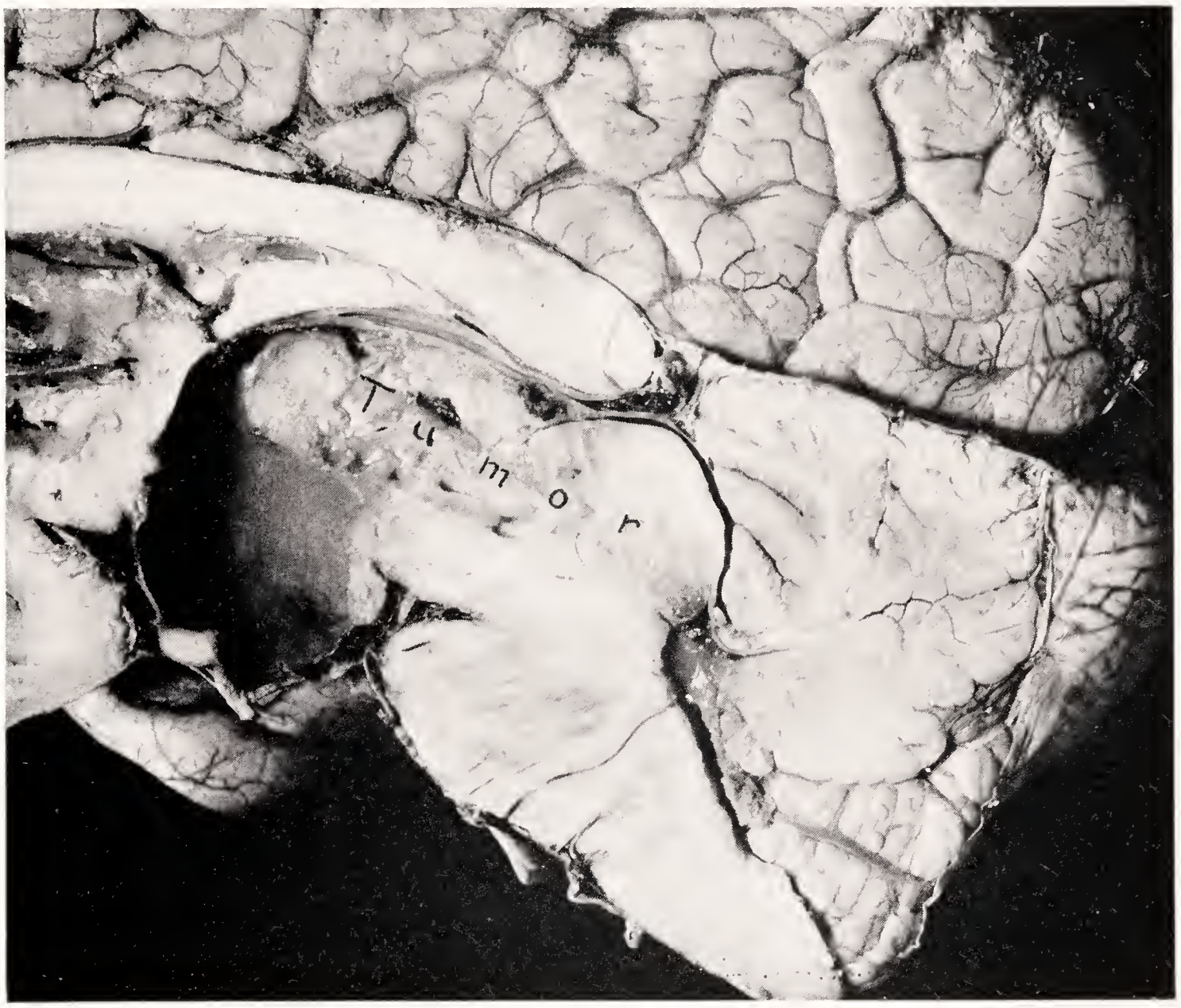

FIG. 52. Example mentioned in text of inoperable pinealoma.

such procedures, however, have been made by W. E. Dandy of Baltimore (1921), by Otfrid Foerster of Breslau (1928), and I have personal knowledge of two highly successful operations performed by my former assistants, Dr. W. P. Van Wagenen of Rochester, New York, and Mr. Hugh Cairns of London. The tumour in Dr. Van Wagenen's case, a "pineoblastoma (?)," was brought to view by a lateral transventricular approach, the soft growth having been removed largely by suction, thus relieving the hydrocephalus.* In Mr. Cairns' case, a "pinealoma of adult

* This case has just been reported in Surgery, Gynecology and Obstetrics, August 1931, LIII, 216–220.

type" exposed by the method which Dandy and Foerster employed after dividing the splenium of the corpus callosum and incising the tentorium, was removed in its entirety.

Statistics.—In 8 of the 14 cases no operation apart from ventriculography was performed, the tumour having been verified at autopsy after varying intervals of time. In 4 others an early fatality ensued after misdirected suboccipital explorations,[38] and in 2 cases I ventured to expose the growth but had to withdraw short of this goal owing to the patient's condition. All of the 6 patients who were operated upon subsequently died in hospital and came to autopsy with tumour verification, so that the case-mortality has been 100 per cent, with a 75 per cent operative mortality. These figures probably account for the fact that during the last three years a more conservative course has been pursued, for in none of the patients admitted to hospital since that time with tumours of quadrigeminal or pineal symptomatology has the lesion been verified, all having been merely decompressed and subjected to radiation in the manner described.

GANGLIONEUROMAS AND NEURO-EPITHELIOMAS

The ganglioneuromas.—These tumours are pathological curiosities and scarcely deserve consideration from a surgical point of view. Two of them occur among the pineal tumours (*cf.* Horrax and Bailey, *loc. cit.*[34] Cases II and III) and would from a surgical standpoint better have been included in the preceding section with the other tumours of the pineal body until we know more about them.

In the third example (Surgical No. 22690), the history of the patient with six years of convulsions, the fact that the tumour which filled the frontal fossa showed calcification on the X-ray, and the general appearance of the sections in spite of the presence of a few possible ganglion cells so closely resembles an oligodendroglioma that it might well enough be put in that category. It is another instance of allowing the microscope to override the more probable diagnosis based on a characteristic life history.

The only unmistakable ganglioneuroma which occurs in our records was a paravertebral lesion[39] and hence does not appear in these tabulations.

The neuro-epitheliomas.—These are tumours with a histological resemblance to the gliomas of the retina which are highly malignant. Of the two examples in the series, one was in the left temporal region and the other arose from the IVth ventricle. In regard to this latter tumour there has been a difference of opinion, it bearing a close resemblance to an ependymoma both in appearance and growth-behaviour.

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[38] Grant, F. C. Cerebellar symptoms produced by supratentorial tumors. A further report. Arch. Neurol. & Psychiat., 1928, xx, 292–308.

[39] Cushing, H., and Wolbach, S. B. The transformation of a malignant paravertebral sympathicoblastoma into a benign ganglioneuroma. Am. J. Path., 1927, III, 203–216.

In 1926, no example of a neuro-epithelioma had been identified and in our monograph[12] the term was merely included in the list of possible tumour-types without illustration. It was placed between medullo-epithelioma and medulloblastoma on the basis of its assumed malignancy, for the so-called neuro-epitheliomas of the retina at least were malignant tumours capable of metastasising. When it came to the German edition of our monograph four years later,[33] a tumour which originally was classi-

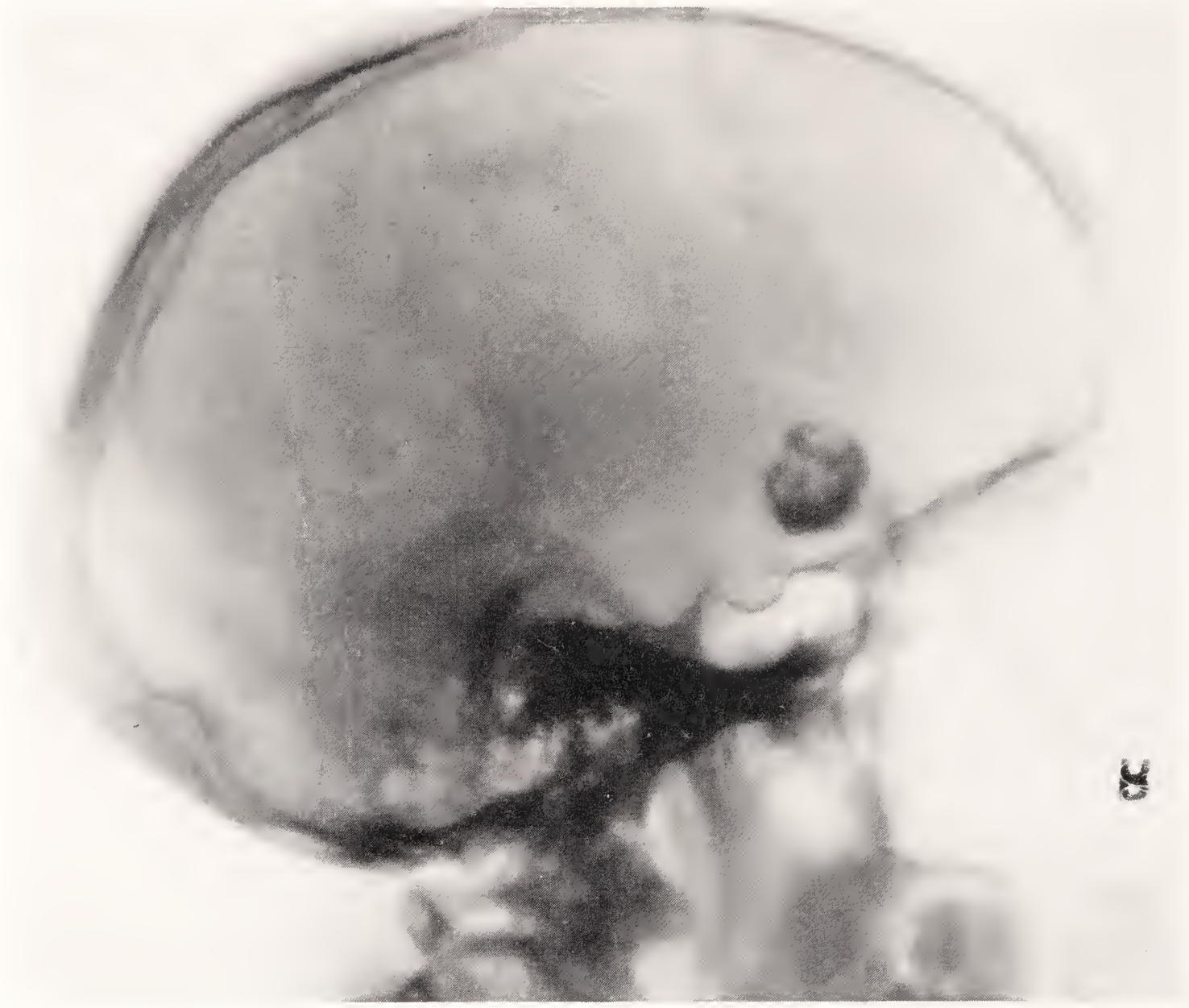

FIG. 53. Roentgenogram disclosing solid mass of calcification deep in temporo-frontal region (*cf.* Fig. 54).

fied as one of three neuroblastomas, had in the interim been restudied and renamed a neuro-epithelioma. It was so entered in the revised list as the single definitely proven tumour of this type. My personal objection to this lay in the fact that the tumour in question was a definitely encapsulated (*cf.* Fig. 54) highly calcified and apparently benign lesion. The history follows:

A man 30 years of age (Surgical No. 15265) entered the hospital *September 27, 1921,* with a history of ten days of headaches and vomiting. He was found to have a choked disc of 6 diopters with questionable weakness of the right side and bilateral hyperactive reflexes. Stereoscopic X-ray films showed a calcified nodule (*cf.* Fig. 53) near the mid-line in the left frontal region.

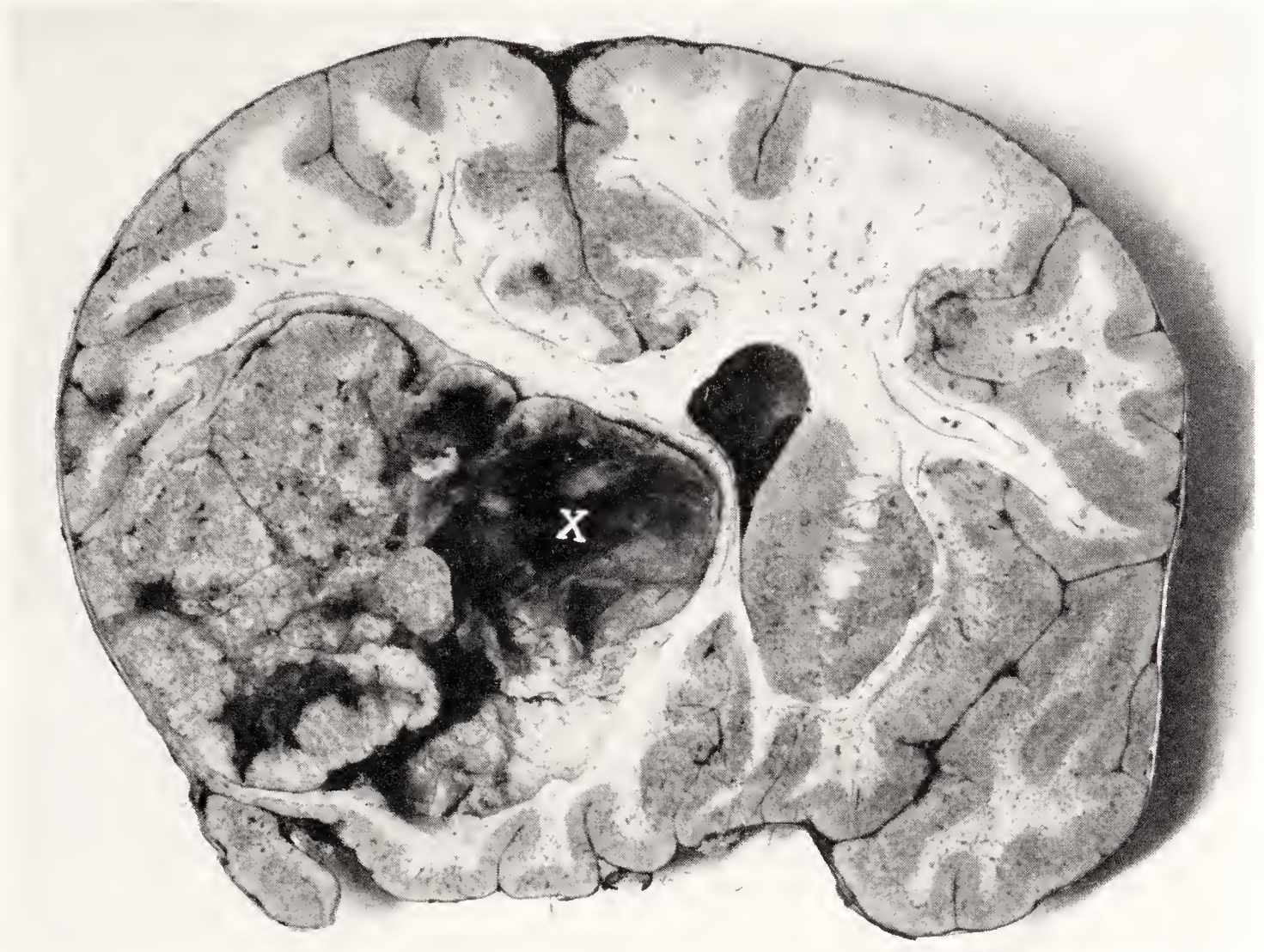

FIG. 54. Coronal section showing the large, well demarcated tumour of the left hemisphere previously diagnosed as neuroblastoma and now as neuroepithelioma. Calcified area centres at X (*cf.* Fig. 53).

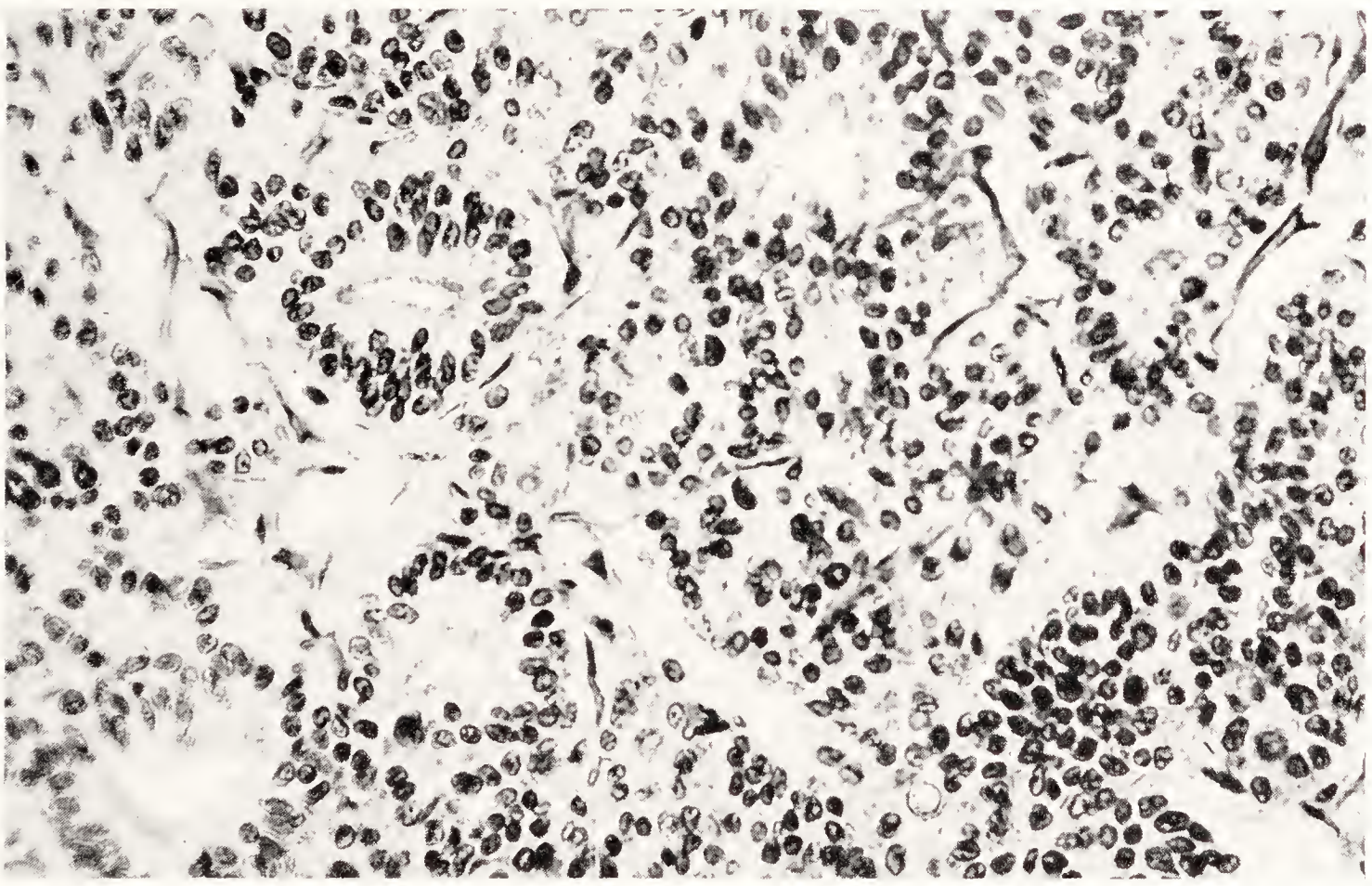

FIG. 55. Typical architecture of neuro-epithelioma from tumour shown in Fig. 54 (hematoxylin and eosin, ×300).

Three days after admission, while still under investigation, the patient had an unlooked-for exitus from sudden respiratory failure. The autopsy disclosed an enucleable tumour (Fig. 54) which must have been present for many years. It was diagnosed in 1921 by Wolbach as a neurocytoma; it was classified by Bailey in 1926 as a neuroblastoma and in 1930 as a neuro-epithelioma—a term quite justifiable on its microscopical architecture (*cf.* Figs. 55, 56) but one which gives a highly misleading impression from the standpoint of prognosis.

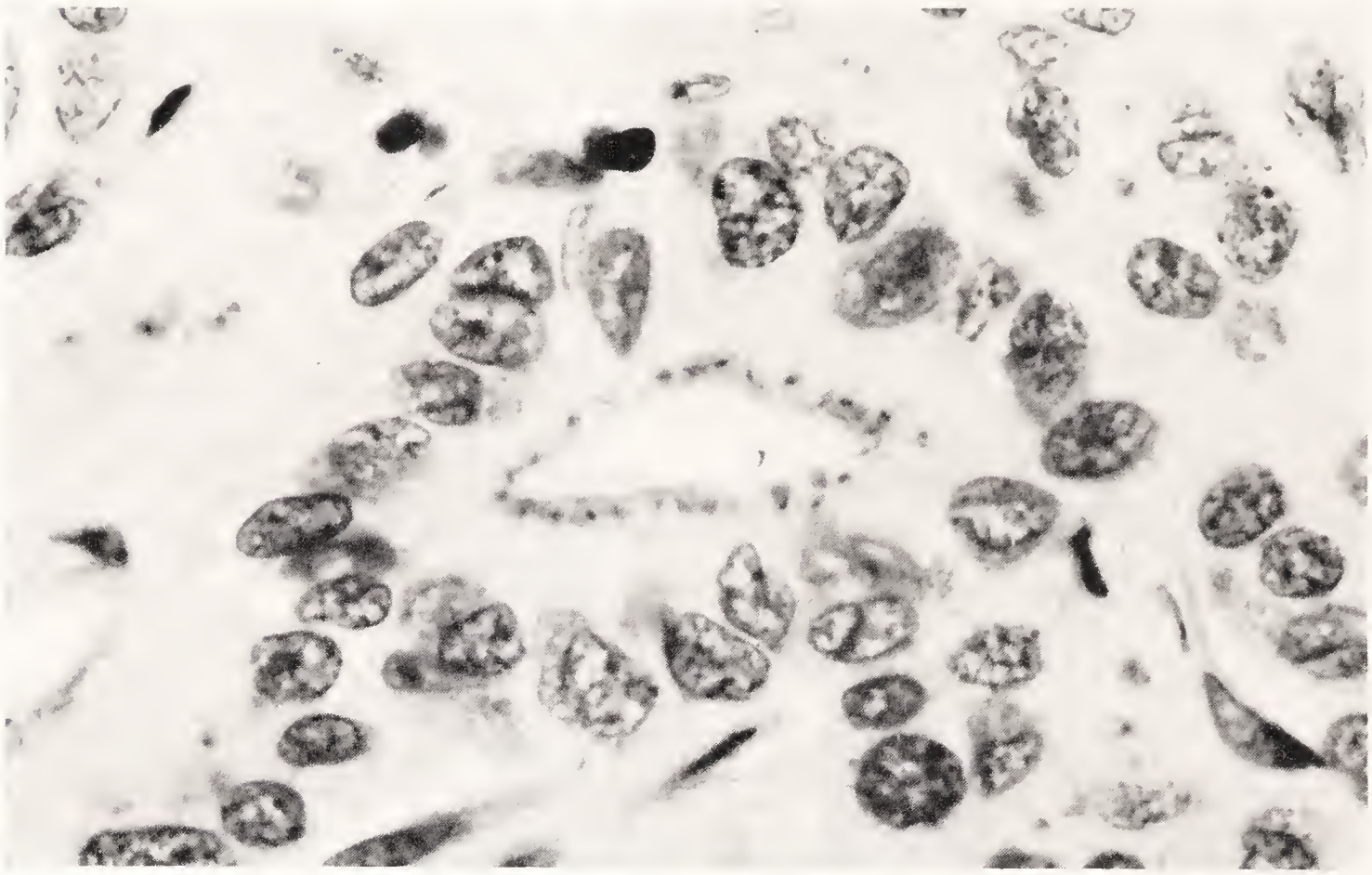

FIG. 56. Same as Fig. 55 (ethyl violet-orange G, ×850), showing rosette at higher power.

Statistics.—The combined mortality percentages for the 862 verified gliomas of all types, 1,173 operations having been performed at different times on 780 patients with 202 postoperative fatalities, give a 25.9 per cent case-mortality and a 17.2 per cent operative mortality. The figures for the past three-year period show 282 operations on 198 new patients observed in this interval, giving a present-day 15.7 per cent case-and an 11.0 per cent operative mortality for gliomas as a whole irrespective of their type and position.

II. The Pituitary Adenomas

As the profession at large becomes increasingly familiar with the various pituitary syndromes, and learns what can be done for those among them which are caused by tumour, patients with these maladies are referred to neurosurgeons in ever increasing number. Hence it need be no matter for surprise that the pituitary adenomas, representing 17.8 per cent of all intracranial tumours, have come to stand second in the list of verified tumours whereas thirty years ago they were practically unknown.* Even the relation of the pituitary "struma" to the syndrome of Marie was then still a matter of speculation. That acromegaly was caused by an adenoma of a particular kind,[40,41] that adenomas of other sorts were far more common and produced a no less characteristic constitutional disorder[42] were facts yet to be worked out; and that these apparently inaccessible tumours would some day come to be successfully operated upon was scarcely to be foreseen.[43,44]

In acromegaly it is the general constitutional disorder which first attracts attention. Hence when the patients are first seen, the small adenoma is likely to be confined within an unexpanded sella and offers a problem which few are as yet rash enough surgically to attack. What on the other hand first calls attention to a chromophobe adenoma, in which the secondary constitutional symptoms are less immediately obvious, is most often impairment of vision from expansion of the lesion to a point at which the overlying chiasm and optic nerves have been seriously stretched and flattened. The ophthalmoscope discloses atrophic pallor of the nerve head, the perimeter usually shows bitemporal field defects, and should the macular bundle have become implicated the capacity for reading ordinary print will have become impaired.

The ophthalmic surgeon is possibly the oldest of surgical specialists and because of his ability to restore sight to the blind he holds a high

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* The comparatively large number of these cases in the tumour series is not wholly fortuitous and ascribable, as has been stated, to the writer's known interest in pituitary disorders in general. Pituitary adenomas are not improbably as common as thyroid adenomas and in future tabulations of intracranial tumours their percentage of incidence is more likely to increase than to diminish.

[40] Bailey and Davidoff. Concerning the microscopic structure of the hypophysis cerebri in acromegaly. Am. J. Path., 1925, I, 185–207.

[41] Bailey and Cushing. Studies in acromegaly. VII. The microscopical structure of the adenomas in acromegalic dyspituitarism (fugitive acromegaly). Am. J. Path., 1928, IV, 545–564.

[42] The hypophysis cerebri. Clinical aspects of hyperpituitarism and of hypopituitarism. J. Am. M. Ass., 1909, LIII, 249–255.

[43] Dott, N. M., and Bailey, P. Hypophysial adenomata. Brit. J. Surg., 1925, XIII, 314–366.

[44] Cushing, H. The pituitary gland as now known. Lancet (Lond.), 1925, CCIX, 899–906.

position in popular esteem. But ophthalmologists have traditionally restricted their surgical field to the orbit and have not ventured to pursue to their source the disorders of vision whose causes lie within the skull. Had they so pursued the sources of choked disc or the sources and causes of the primary optic atrophies, they might well enough have long preceded the neurosurgeon in those tasks which permit him to share in the gratifying occupation of restoring vision; for the extent this is attained is the measure of success of an operation for a pituitary adenoma.

In former days when surgeons were cautiously beginning to attack these tumours, a transphenoidal operation by way of the nasal cavities was favoured. The chiasmal region was thought to be well out of reach and even had it been more readily exposed, it was taken for granted that the laying bare of a pituitary tumour from above would be more likely further to damage the nerves and chiasm than to relieve the damage already done.

It is unnecessary here to review the various types of transphenoidal operation that have been undertaken. Every surgeon who was interested developed his own special technique. For cases in which the sella was greatly expanded the writer long favoured a procedure which gave a fairly satisfactory view without injury to the mucous membrane lining the nasal septum, and this operation first described in 1914[45] and subsequently somewhat simplified served admirably for its day. It had the comparatively low mortality rate of 5 or 6 per cent and under favourable circumstances was followed by many temporarily brilliant results.

One drawback to the transphenoidal procedure lay in the fact that many of the patients had previously been subjected to intranasal operations which added greatly to its difficulties; and for the same reason, as former patients began to return because of recurrence of their symptoms, the previous operation through the nose could not easily be repeated. Hence we have gradually swung away from the transphenoidal route and for the past few years it has been almost entirely superseded by what for a better name is called a unilateral, osteoplastic "transfrontal method" of approach, a procedure which has had various sponsors.

There are numerous tumours which affect the chiasm by pressure and which fail to expand the sella turcica.[46] These tumours, some of them pituitary adenomas, are obviously unapproachable through the nasal cavities, and in the course of their study sufficient experience was gained with the exposure of the chiasmal region from above to make it the favoured route for all pituitary adenomas. Meanwhile, much has been learned regarding the sources of failure in some of the early transphenoidal operations; for not infrequently when a large soft adenoma had been freely sucked out of the expanded sella from below, the expected filling out of the defective fields of vision for some unaccountable reason failed to take place.

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[45] Surgical experiences with pituitary disorders. (Weir Mitchell lecture). J. Am. M. Ass., 1914, LXIII, 1515–1525.

[46] *Cf.* The chiasmal syndrome of primary optic atrophy and bitemporal field defects in adults with a normal sella turcica. Arch. Ophth., 1930, III, 505–551, 704–735.

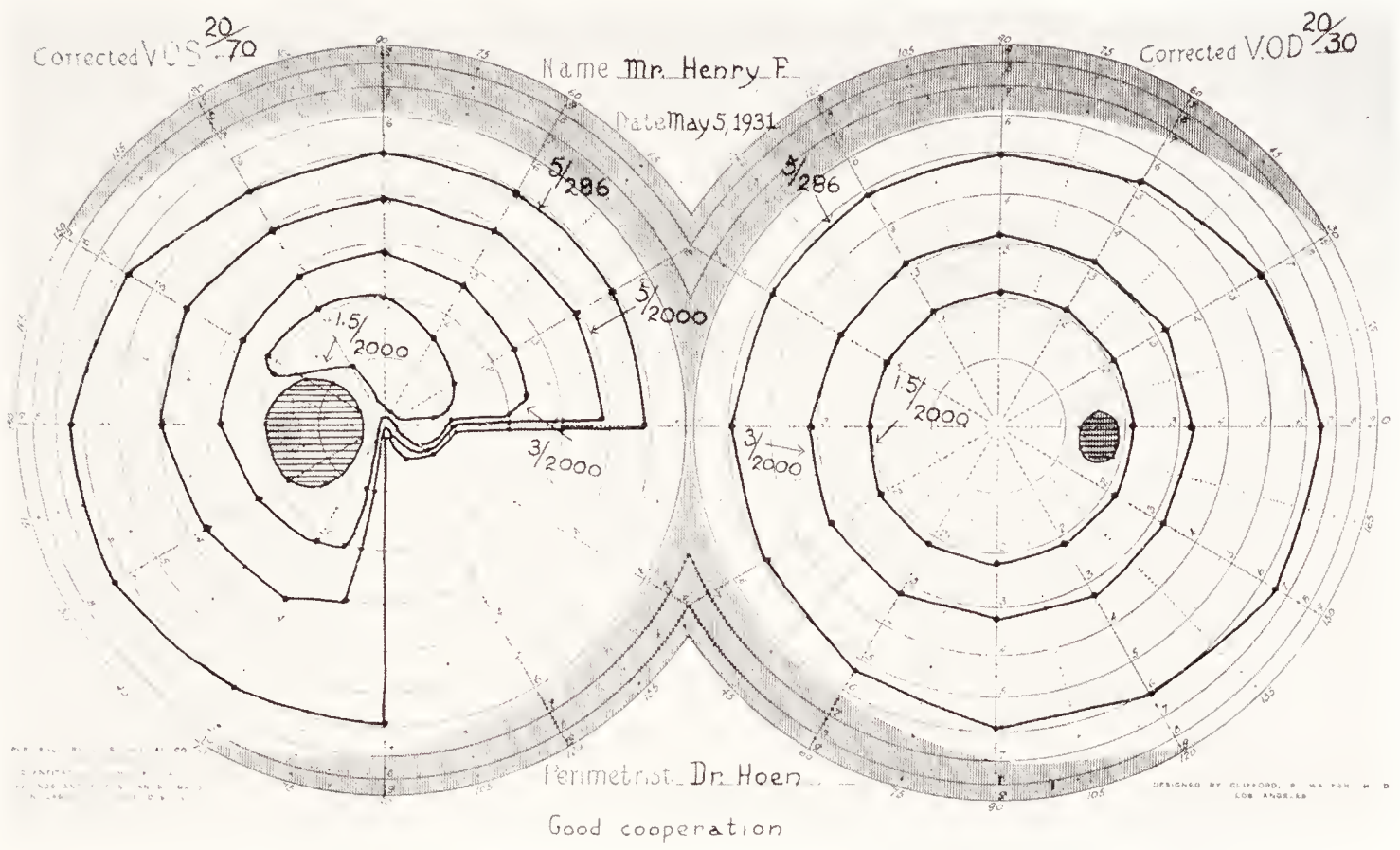


FIG. 57. Preoperative lower left nasal field defect, an unusual consequence of a pituitary adenoma.

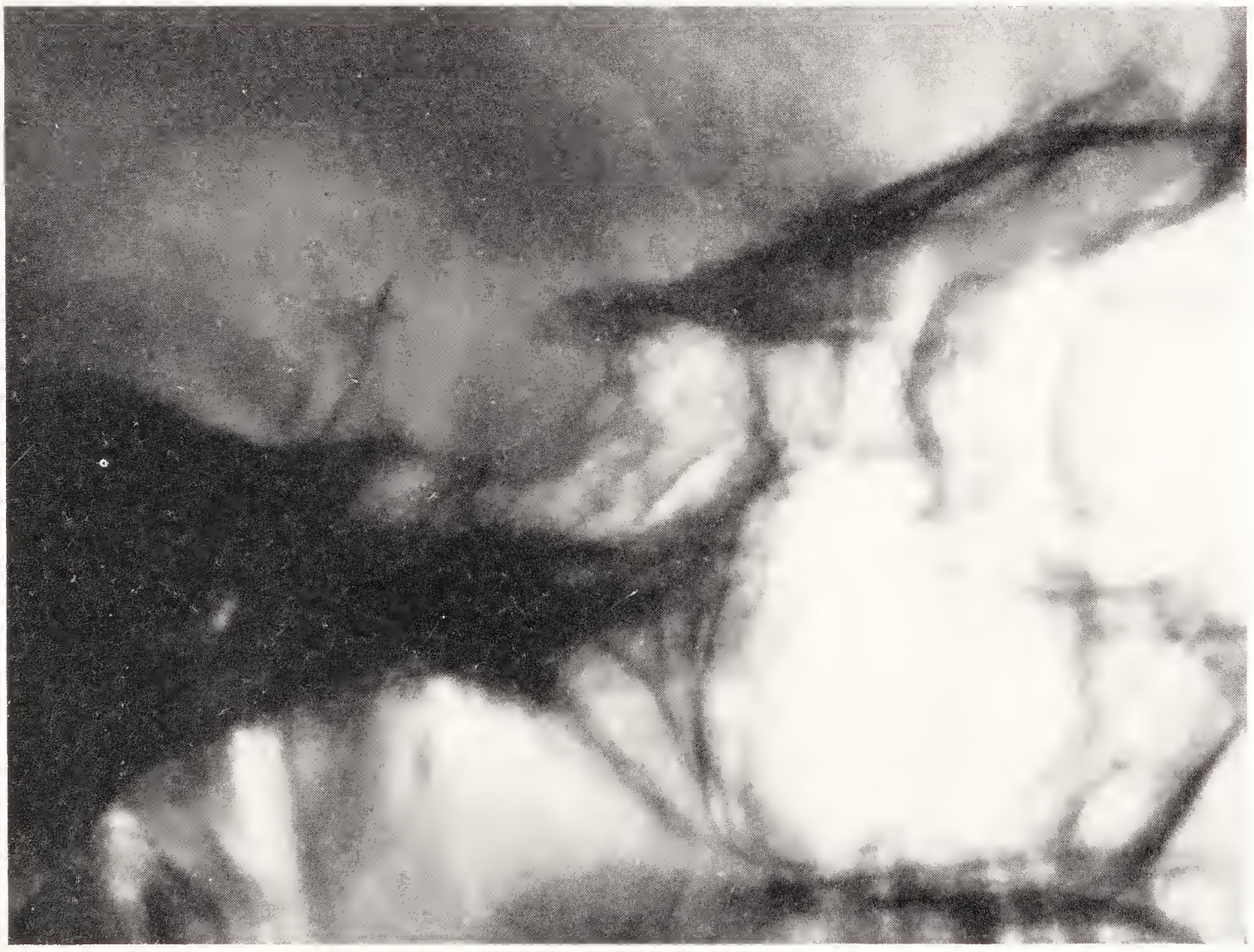


FIG. 58. Portion of cranial X-ray (nat. size) disclosing unsuspected enlargement of sella characteristic of adenoma.

It has of course been long known that adenomas of both chromophobe and chromophile types* may occasionally burst through the diaphragma sellae and extend widely into the cranial chamber.[47] This sometimes occurs laterally so that the growth, on one side or the other, or indeed on

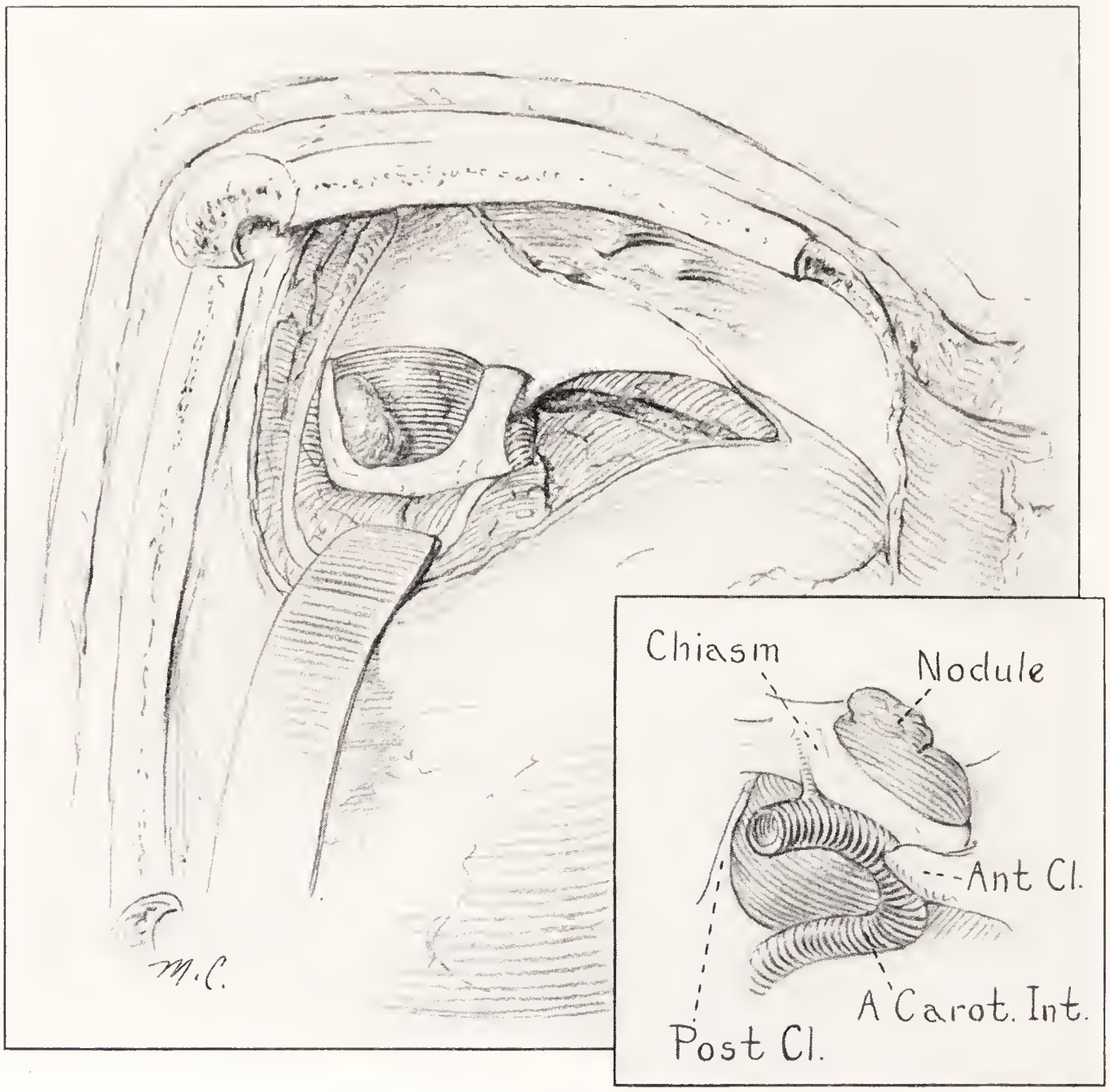


FIG. 59. Sketch of operative field showing nubbin of pituitary adenoma projecting through dural diaphragm and partly enveloping the left optic nerve (*cf.* Fig. 57). Insert gives imaginary lateral view from right side.

both sides, may come to engulf the internal carotid arteries. But it is perhaps more common for the adenomatous extrusion to squeeze its way upward through the normal opening in the diaphragma for the pituitary stalk so that it is often median in position. In our recent series of cases

* For simplicity in the present calculations the 23 "mixed" adenomas (*cf.* Dott and Bailey). Hypophysial adenomata.[43] Also: Bailey and Cushing,[41] associated with what we have called "fugitive acromegaly" have been fused with the adenomas of chromophobe type as their surgical problem is identical.

[47] Cushing and Davidoff. The pathological findings in four autopsied cases of acromegaly with a discussion of their significance. Monogr. Rockefeller Inst. M. Research, No. 22, 1927, (Cases II and III). Also: The pituitary body and its disorders. J. B. Lippincott Co., Phila., 1912, (Cases II and V). Also: Acromegaly from a surgical standpoint. Brit. M. J., 1927, II, 1–9, 48–55.

in which the tumour has been exposed from above, a goodly number of such extrusions have been successfully tilted out from under the chiasm or from under one or the other optic nerve with results, so far as concerns the restoration of field defects, that could never have been attained by even the most radical transphenoidal operation. A recent example of this may be cited.

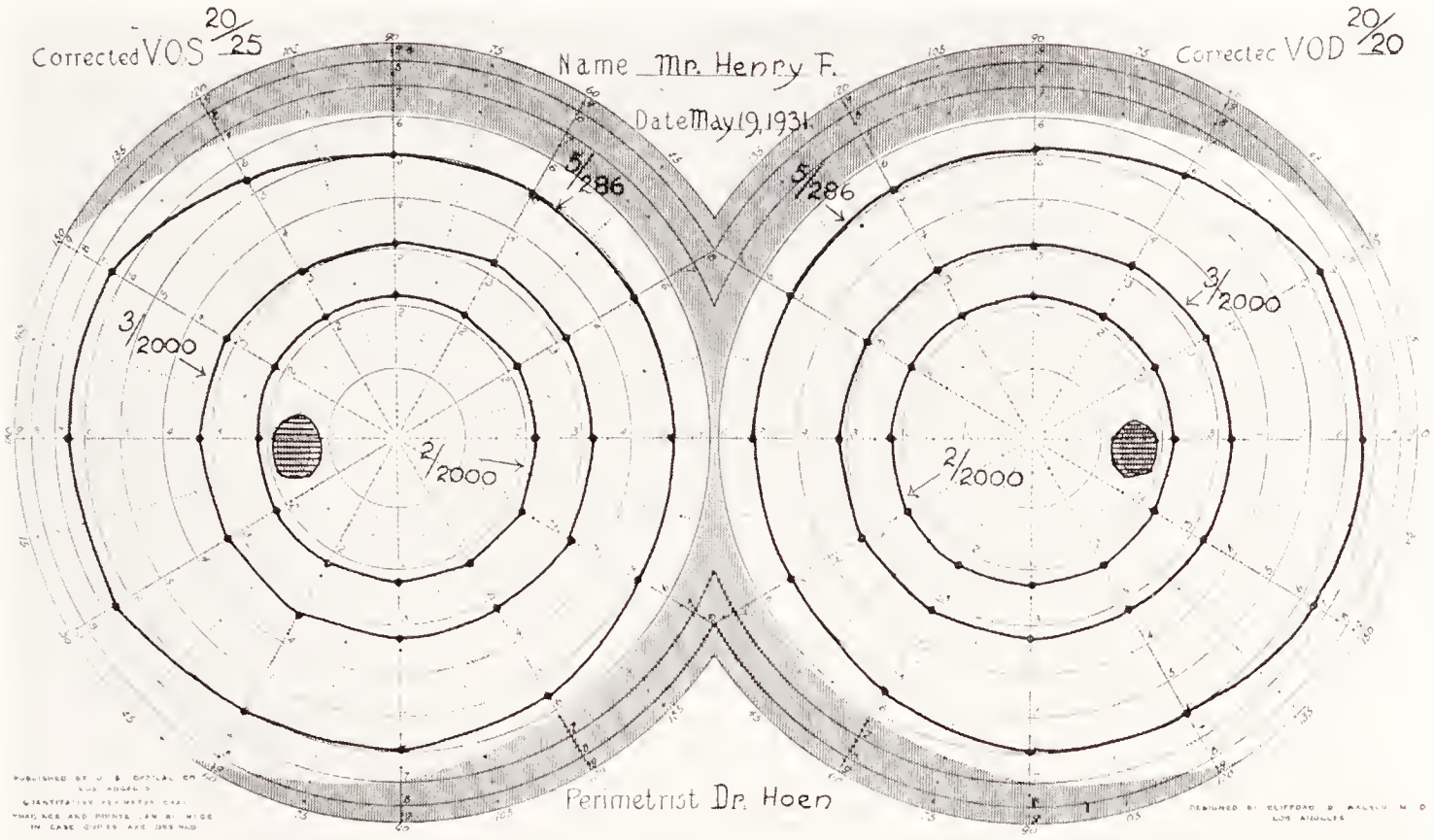


FIG. 60. Postoperative fields of vision for comparison with those shown in Fig. 57.

A 22 year old young man (Surgical No. 38756) was admitted on *May 5, 1931*, complaining of failing vision in the left eye of only three weeks' duration. Apart from this he was in perfect health. As had been previously observed by two ophthalmologists, he was found to have a lower nasal quadrantal field defect in the left eye with a paracentral scotoma (Fig. 57). Moreover there was haziness of the disc with tortuosity and engorgement of the vessels which suggested an early papilloedema. There was nothing in all this to suggest a pituitary disorder and the X-ray disclosure of an expanded sella (Fig. 58) came as a surprise.

Though a pituitary adenoma would scarcely be expected to produce a field defect of this sort, nevertheless an exploratory operation was advised. This was carried out on *May 12* when a nubbin of adenoma was found projecting through the distended diaphragma sellae, partly enveloping the left optic nerve (Fig. 59). The diaphragma was electrically incised and after the soft intrasellar adenoma had been sucked out the nodule was easily dislodged from under the nerve and removed.

So soon as the wound was closed and the drapings removed, tests for vision showed that the field defect had disappeared; and a few days later when a more exact perimetric study was made, the fields were found to be normal in all respects (Fig. 60). His postoperative course was uneventful, the wound healed with an invisible scar, and at the end of two weeks he was able to leave the hospital (Fig. 61).

Some neurosurgeons with wide experience prefer a more laterally placed and larger osteoplastic flap than that which we utilize at the Brigham Hospital. What is more, some of them advocate the deliberate sacrifice of the more seriously impaired nerve to give better access to the tumour; and the osteoplastic flap accordingly is made on the side, right or left, corresponding to the eye whose vision is chiefly involved. For my own part, I feel that a right-handed person when working in so small and restricted a field does better through a right-sided opening; and since experience shows, not only that early restoration of vision may sometimes occur in an eye practically blind before operation, but also that the more seriously impaired eye may not infrequently exceed the other in rapidity of recovery it would seem unwise to sacrifice one of the nerves even did this manoeuvre give better access to the growth. This, as a matter of experience, it does not do when the region is approached from the front rather than obliquely from the side. Another objection to the latter approach is that a large surface of the brain is temporarily denuded and elevated so that postoperative oedema from contusion is far more likely to occur.

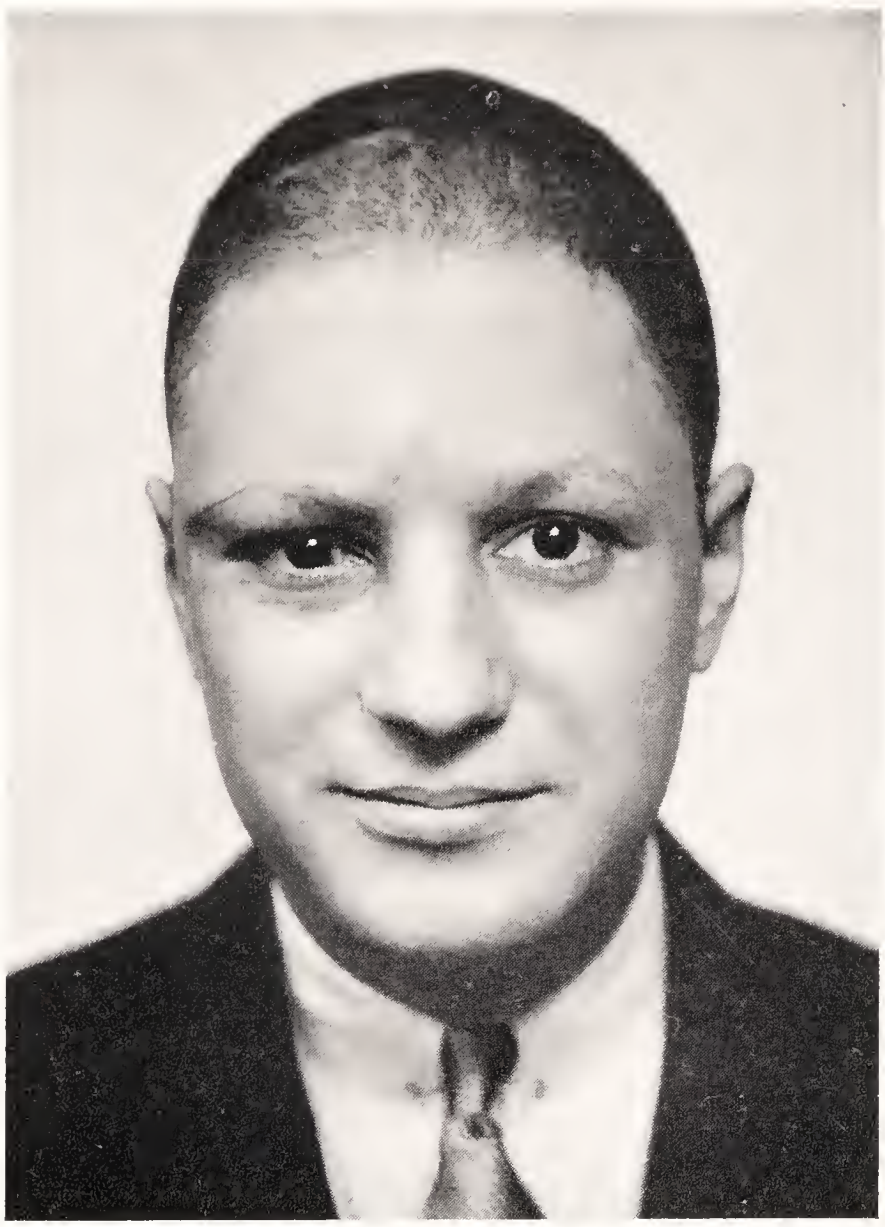


FIG. 61. Patient on discharge showing position of near-invisible scar.

The chief objection to a chiasmal exposure by the transfrontal or any other procedure, which is accompanied by the escape of a large amount of cerebrospinal fluid thereby leaving the brain and its dural covering under subnormal tension, is the likelihood of a postoperative clot. This accident when overlooked and unsuspected has twice been the cause of fatality, and it has been necessary to re-elevate the flap for clot or suspected clot in about one out of every ten cases. In spite of all care in closure, this is a risk therefore which approximates the risk of meningitis by the old transphenoidal route.

There however can be no comparison between the exactitude of the two procedures, the transphenoidal operation being conducted through a

small tubular opening, whereas every step of the transfrontal procedure is directly under the observer's eye. What is more, should the adenoma prove to be highly vascular, bleeding is far more easily controlled from above than from below, electro-surgical coagulation being of great aid in this direction.

For the purpose of comparing the mortality figures for the two types of operation, Mr. W. R. Henderson has just completed an analysis of our case records for the decade from May 1, 1921, to May 1, 1931, for it was during this period that the operation through the nose was being superseded by that from above. In this decade 206 patients were operated upon 227 times with 11 fatalities giving a 5.3 per cent case-mortality and a 4.8 per cent operative mortality. On separating the 206 patients into their 168 chromophobe and 38 chromophilic or acromegalic types, the latter prove to have a considerably higher mortality rate as shown by his following figures:

For the 168 *chromophobe adenomas* during the decade, there were 97 transphenoidal operations with 3 fatalities (3.1 per cent) and 88 transfrontal operations (21 of them for recurrence of symptoms in patients previously operated upon by one route or the other) with 4 fatalities (4.5 per cent). The combined figures for the adenomas of this type, however approached, give a total case-mortality of 4.2 per cent and an operative mortality of 3.8 per cent.

For the 38 *chromophile adenomas*, there were 31 transphenoidal operations with 2 fatalities (6.5 per cent) and 9 transfrontal operations (three of them for recurrence) with 2 fatalities (22.2 per cent), giving a total case-mortality for the acromegalic patients of 10.5 per cent and an operative mortality of 10 per cent.

The 5 fatalities after the 128 transphenoidal operations were from meningitis; the 6 fatalities after 97 transfrontal operations were due to postoperative clot in 4 and cerebral oedema associated with an overlooked intracranial extension of the adenoma in 2 instances.

That the proof of the pudding is in the eating is an old adage; and more important than these figures relating to mortality percentages are Mr. Henderson's disclosures regarding the postoperative improvement in vision. Whereas 37 per cent of the patients after transphenoidal operations and 42 per cent after transfrontal operations showed considerable or marked improvement in vision, only 9 per cent of the transphenoidal operations, in contrast to 21 per cent of the transfrontal operations, were followed by restoration of the visual fields and acuity essentially to normal. It is in this respect that the transfrontal procedure definitely takes precedence over the other.

Still another reason, favourable to the exposure of these tumours from above, is that only by this approach can one determine whether an extracapsular extension of the growth has taken place, and in cases of long standing, the possibility of this must always be borne in mind. Reference was made in the statistics of the decade just reviewed to the fact that large intracranial extensions of the lesion were the cause of death in two instances. One of them was a particularly harrowing experience;

A brilliant young college professor (Surgical No. 32647) began in 1925 to show signs of pituitary insufficiency with impairment of vision, but it was not learned until 1928 that the sella was greatly enlarged. Radiotherapy was advocated and this was kept up intermittently for the next two years. There was apparent improvement for a time with periodic fluctuation of symptoms, but on the whole they were progressive. Not until his general health became so seriously impaired that he was unable longer to hold his position was the possibility of relief by surgical intervention accepted.

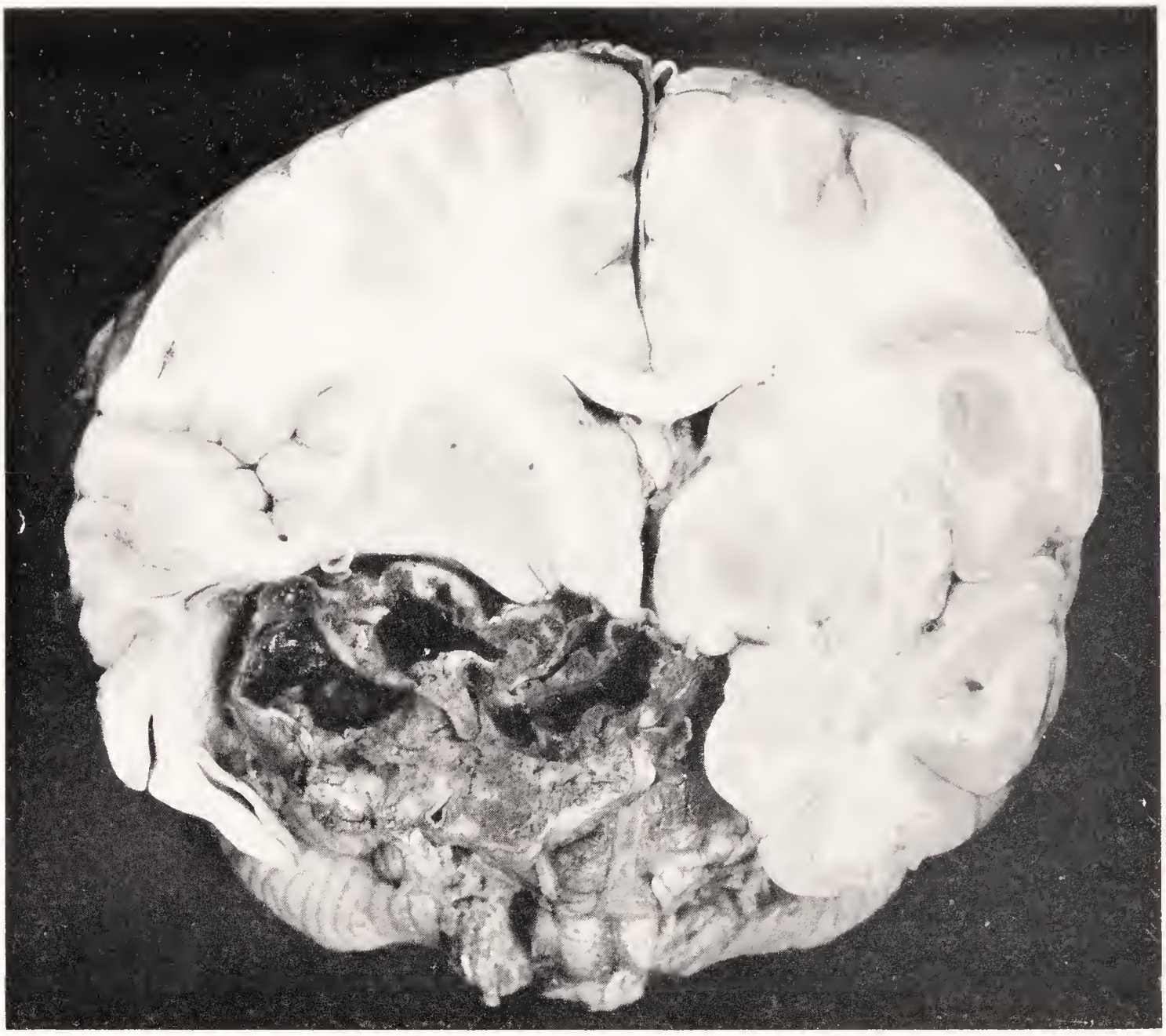


FIG. 62. A large, unsuspected adenomatous expansion of a pituitary adenoma into right temporal lobe.

On *February 26, 1930,* a large intrasellar adenoma was disclosed by the transfrontal route but an unusual degree of intracranial tension was encountered making the exposure difficult and unsatisfactory, though the growth was thoroughly excavated by suction freeing the nerves from pressure. He did badly afterward and fearing the formation of a clot, the flap was reëlevated on the following day, evidence of cerebral oedema rather than clot being found. Because of this, a right subtemporal decompression was made exposing a tense temporal lobe, but this failed to give relief.

At autopsy a large, unsuspected temporal expansion of the adenoma was found (Fig. 62). Had this been recognized during life, it might have been easily

exposed and sucked out by a superficial incision through the temporal cortex at the time of the emergency decompression.

The story of this case not only illustrates the futility of prolonged radiotherapeusis, particularly for adenomas of chromophobe type, but shows at the same time that operations for adenoma are not always a child's play. That such an intracranial expansion of the tumour into the

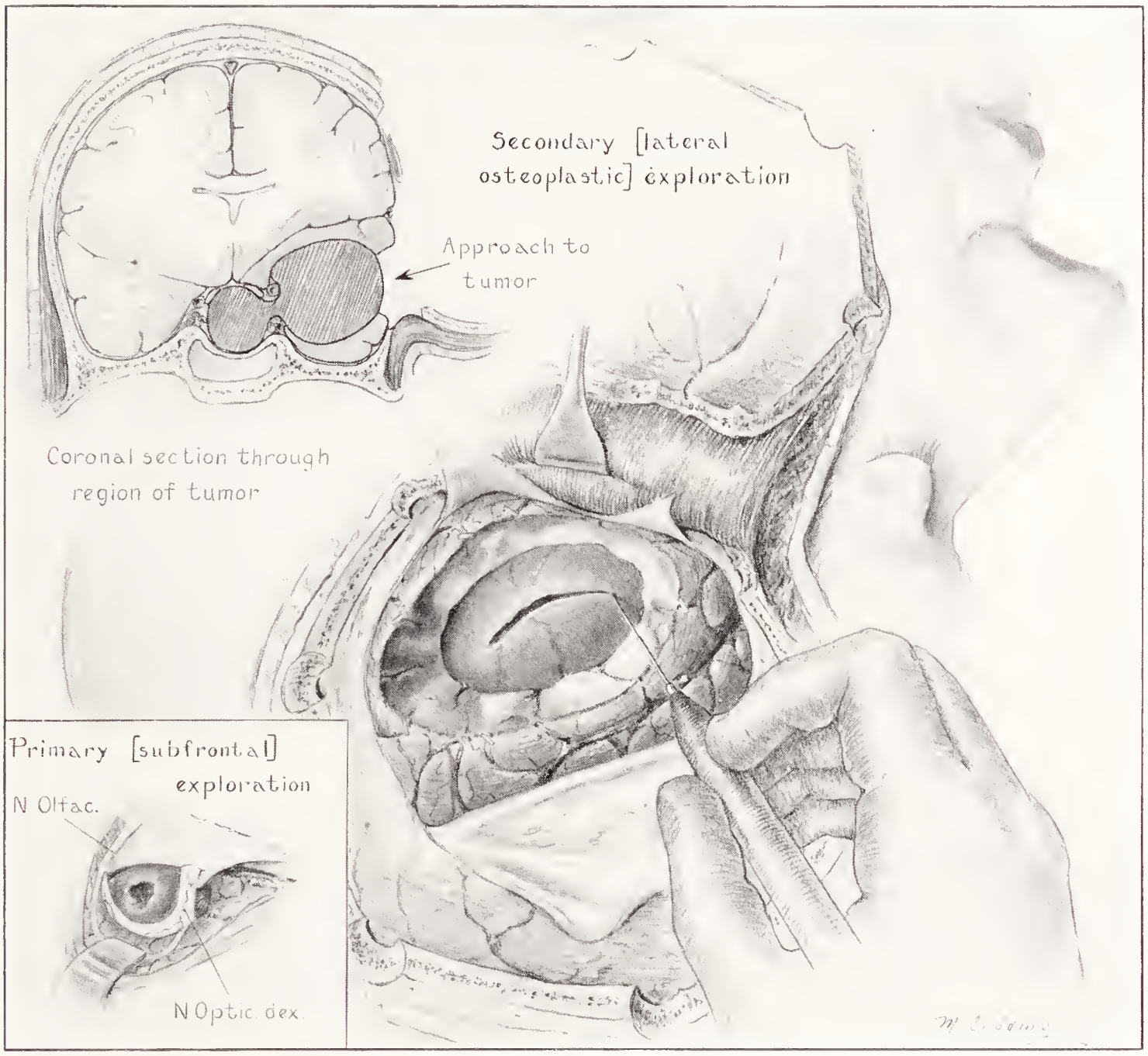


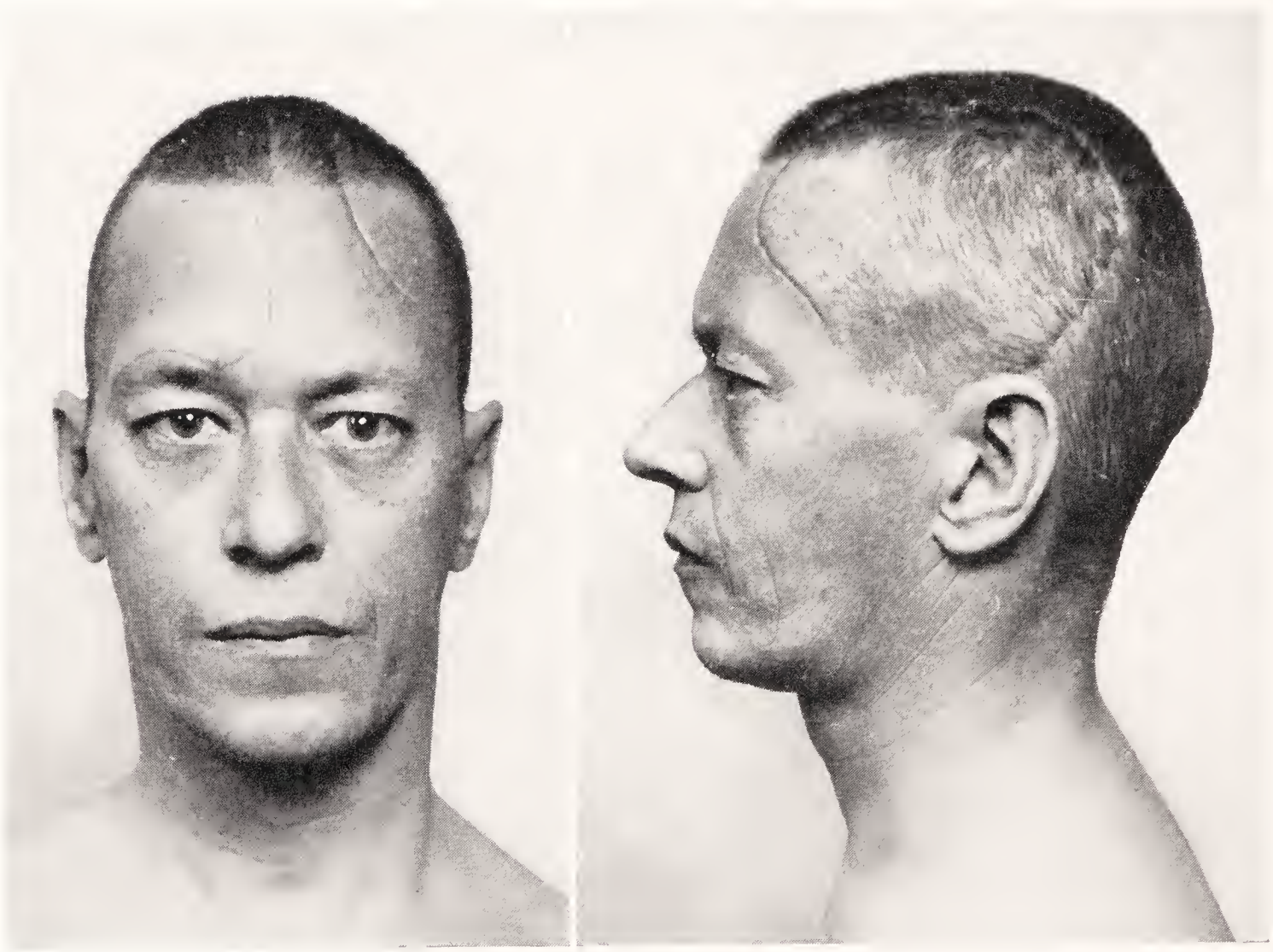
FIG. 63. Sketches of the two-stage operation in the first of which the temporal expansion of the tumour was unsuspected. An intrasellar extirpation of the lesion failing to relieve symptoms, ventriculography disclosed a large temporal expansion of the growth (*cf.* Fig. 64).

temporal lobe, if clinically recognized, is by no means a surgically hopeless problem, is shown by the following account of a precisely similar lesion:

A tall spare man, 41 years of age (Surgical No. 37497), entered the hospital *October 21, 1930,* because of blurring of vision, failing memory and lassitude. He was found to have a bilateral primary optic atrophy without papilloedema, a widely ballooned sella measuring 24 by 34 mm. and a right upper quadrantal homonymous hemianopsia.

On *November 4,* the lesion was readily exposed by the customary right trans-

FIG. 64. Showing empty sac of temporal expansion of adenoma (similar to that in Fig. 62) after removal at secondary operation (nat. size).



FIGS. 65, 66. Patient on discharge after dual operation for pituitary adenoma with intracranial extension.

frontal operation, the intrasellar portion of the growth being sucked out in the usual fashion. There was no visible evidence of tumour extension to the left of the chiasm to explain the homonymous field defects.

No improvement followed this operation and on *November 28* ventriculograms were made disclosing a displacement of the third ventricle to the right with filling defect of the left temporal horn. An immediate left osteoplastic exploration was made, and when the temporal lobe was "uncapped" a large adenomatous tumour was exposed (Fig. 63). The capsule was incised and its contents evacuated by suction. The sac (Fig. 64) was then drawn out and electrically amputated in the vicinity of the sella.

A temporary aphasia followed this operation but the patient had recovered from this by the time of his discharge on *December 23, 1930* (Figs. 65, 66). He continues in good health, and in spite of the persistence of the hemianopsia his visual acuity is unimpaired.

So far as concerns radiotherapeusis, at least in the case of the chromophobe adenomas,* it is safe to say that it will come to be discarded just as radiation for exophthalmic goitre has been, so soon as neurosurgeons as a class perfect themselves in the details of the operative procedure. It may reasonably be assumed that in those clinics where radiation for these lesions is still routinely advocated, the surgical results have been poor and the mortality disturbingly high.

Statistics.—The figures for the entire series of recorded adenomas of both types are as follows: Eleven of the 360 verified tumours were disclosed at autopsy without preceding operation. The remaining 349 patients were operated upon 403 times with 25 deaths in hospital giving a 7.1 per cent case-mortality and a 6.2 per cent operative mortality.

Unfortunately the two fatalities due to large intracranial expansions of the adenoma fall in the last three-year period (July 1, 1928–July 1, 1931) during which there were 59 patients with 70 operations and 4 fatalities giving a present-day 6.8 per cent case- and a 5.7 per cent operative mortality. Should this recent period, for better comparison with the results in the entire series, have been extended back another six months to January 1, 1928, it would have included 79 patients with 103 operations and the same 4 fatalities, giving a 5.2 per cent case- and a 3.9 per cent operative mortality. We may confidently expect that these figures will soon approximate 1 or 2 per cent.

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* The chromophile adenomas in our experience appear to be more definitely susceptible to radiation.

III. The Meningiomas

Reasons for the substitution of the name "meningioma" for the customary "dural endothelioma" were given ten years ago in my Cavendish Lecture.[48] The term has the advantage of brevity without histopathological pretensions, the histogenesis of the lesions being still under dispute; and though it is distasteful to some, it connotes a lesion of definite type and origin which is as much as one can ask of any family designation. Leptomeningioma, employed by Learmonth, merely lengthens the name unnecessarily for the pachymenix has no (at least undisputed) primary tumours, and meningeal or arachnoidal fibroblastoma favoured respectively by Penfield and by Mallory are even more cumbersome than dural endothelioma. What is more, this latter term is insufficiently comprehensive for there are numerous sub-types—angioblastic,[49] chondroblastic and osteogenic as well as fibromatous and sarcomatous.[50]

Though these tumours may arise from the leptomeninges almost anywhere, those within the cranial chamber have their favoured sites and a corresponding symptomatology. As experience grows, this becomes more and more evident. Even in the absence of roentgenological indications of their precise point of origin as betrayed by cranial abnormalities,[51] the several syndromes according to situation tend to become increasingly clear. Tumours involving the frontal lobes are particularly common and are very easily overlooked since the symptoms they provoke simulate paresis or other mental disorders.

Whereas in our series of cases the meningiomas represent only 13.4 per cent of all tumours, Davidoff* has pointed out that 30.6 per cent of the tumours in the collection of the Psychiatric Institute of New York are of this nature and, as would be expected, were so situated as to involve the frontal lobes. Thus in different collections the regional percentage of tumours of the same kind as well as their total number may be easily affected by selective influences.

Though the meningiomas are supposedly the most favourable of all intracranial tumours for surgical attack, all things considered they offer more difficult technical problems for successful removal than do tumours of any other kind. This is due to the huge size they may attain, to the ac-

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[48] The meningiomas (dural endotheliomas): their source and favoured seats of origin. Brain (Lond.), 1922, XLV, 282–316.

[49] Bailey, Cushing, and Eisenhardt. Angioblastic meningiomas. Arch. Path., 1928, VI, 953–990.

[50] Bailey. Intracranial sarcomatous tumors of leptomeningeal origin. Arch. Surg., 1929, XVIII, 1359–1402, (Case 6).

[51] Putnam, T. J., and Sosman, M. C. Roentgenological aspects of brain tumors-meningiomas. Am. J. Roentgenol., 1925, XIII, 1–10.

* Davidoff, L. M. Brain tumors, their pathology, symptomatology, diagnosis and prognosis. Psychiatric Quart., 1930–1931, IV, V.

companying great vascularity of the adjacent tissues, and to their tendency to involve one or another of the major venous sinuses, more particularly the sagittal. The operations in consequence may be among the most formidable and immediately hazardous the surgeon is called upon to undertake. They are practically the only intracranial tumours for which it is desirable routinely before operation to prepare for the possible need of a blood transfusion. And they remain today practically the only tumours in which one may still occasionally feel obliged to resort to the old-time two-stage operation.

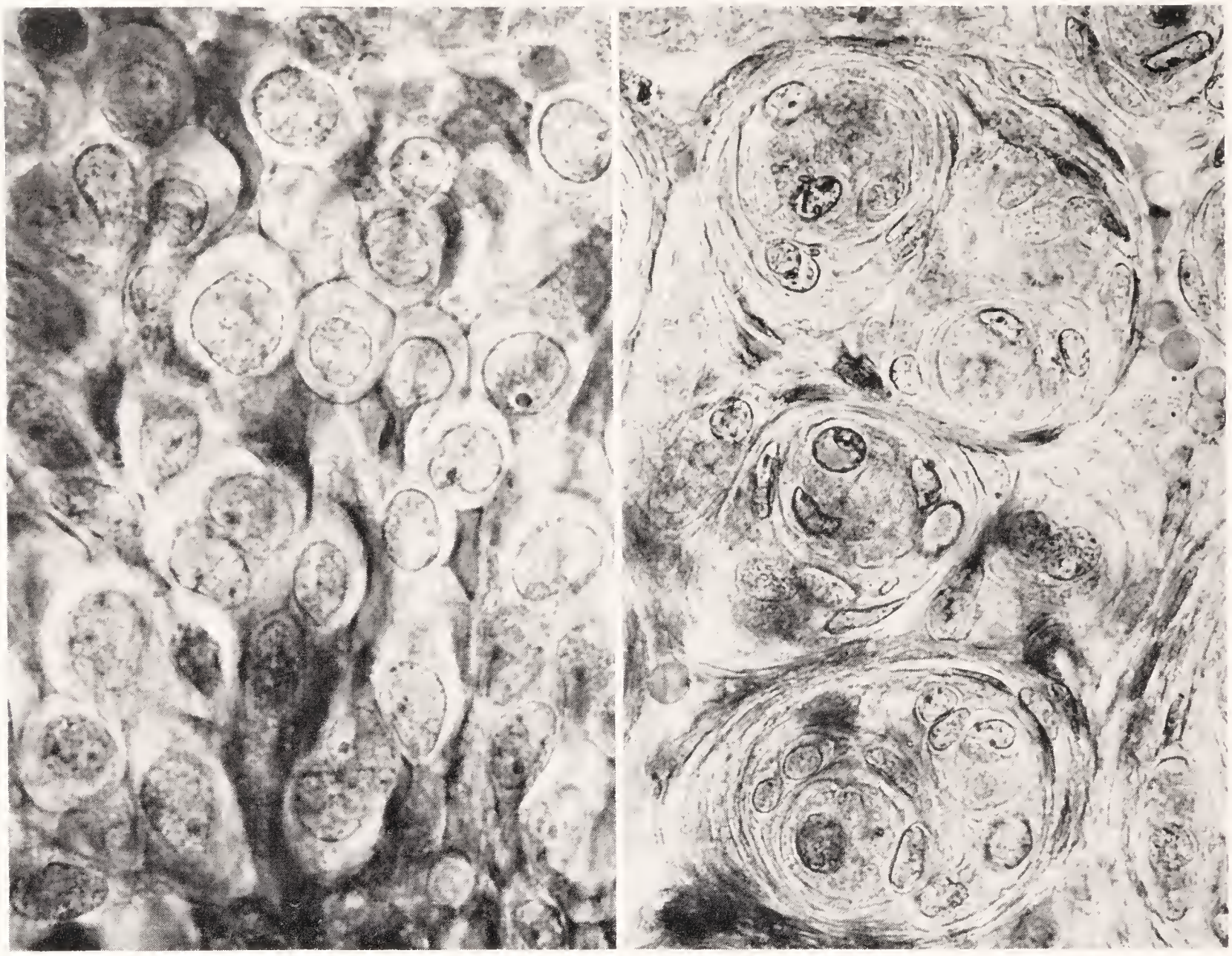
FIG. 67. Firm occipital meningioma from which the wedge shown was electrically removed to facilitate extirpation of the growth.

In addition to all this, no tumours require such detailed after-care either to avoid postoperative complications from secondary oedema, or to offset the tendency of cerebrospinal fluid fistulae to form. And what is still more important, these supposedly benign lesions are disconcertingly prone to recur, even with great rapidity. A recent example of this follows:

A young woman (Surgical No. 37217) with a highly advanced choked disc and a left homonymous hemianopsia was operated upon *September 8, 1930,* when a large firm occipital and parasagittal meningioma not involving the bone was removed apparently in its entirety (Fig. 67). She made a temporary perfect recovery with restoration of normal fields of vision.

The tumour proved to be one of the highly cellular "sarcomatous" varieties of meningioma (*cf.* Fig. 68) with no tendency to whorl formation; and since the capsule had been broken into in the process of dislodging the huge growth, the outlook was dubious.

After the lapse of 4 months a nodule was removed from the sub-galea where evidently it had been "seeded." There was no suspicion at this time of local recurrence of the main lesion, but two months later she once more began to be



FIGS. 68, 69. On the left is shown (supravital method, ×850) a highly cellular rapidly recurring meningioma (Surgical No. 10681) with elements resembling epithelial cells having abundant mitoses. Patient living after 12 years and 12 operations for recurrences. On the right (for comparison) is shown (supravital method, ×600) a typical benign meningioma (Surgical No. 38818) of customary type with characteristic whorl formation.

conscious of constriction of the fields of vision to the left and, finally, when a choked disc again became apparent, she reëntered the hospital for the third time.

On *June 1, 1931*, only eight months after the primary operation, the flap was again elevated and a tumour of approximately the same size and precisely the same appearance was found to have reformed. It was again most carefully enucleated so far as could be told in its totality (Fig. 70), leaving the normal

appearing falx widely uncovered. She once more has made a prompt and perfect temporary recovery.

We have had cases in the series in which successive enucleations of this sort have been performed, each time in apparent totality, only to be followed by disappointment. One of these patients whom I have desperately fought for has had, since the time of his first operation in 1919, eleven subsequent operations for massive recurrences of the "sarcomatous" lesion, 1,464 grams of tumour having all told

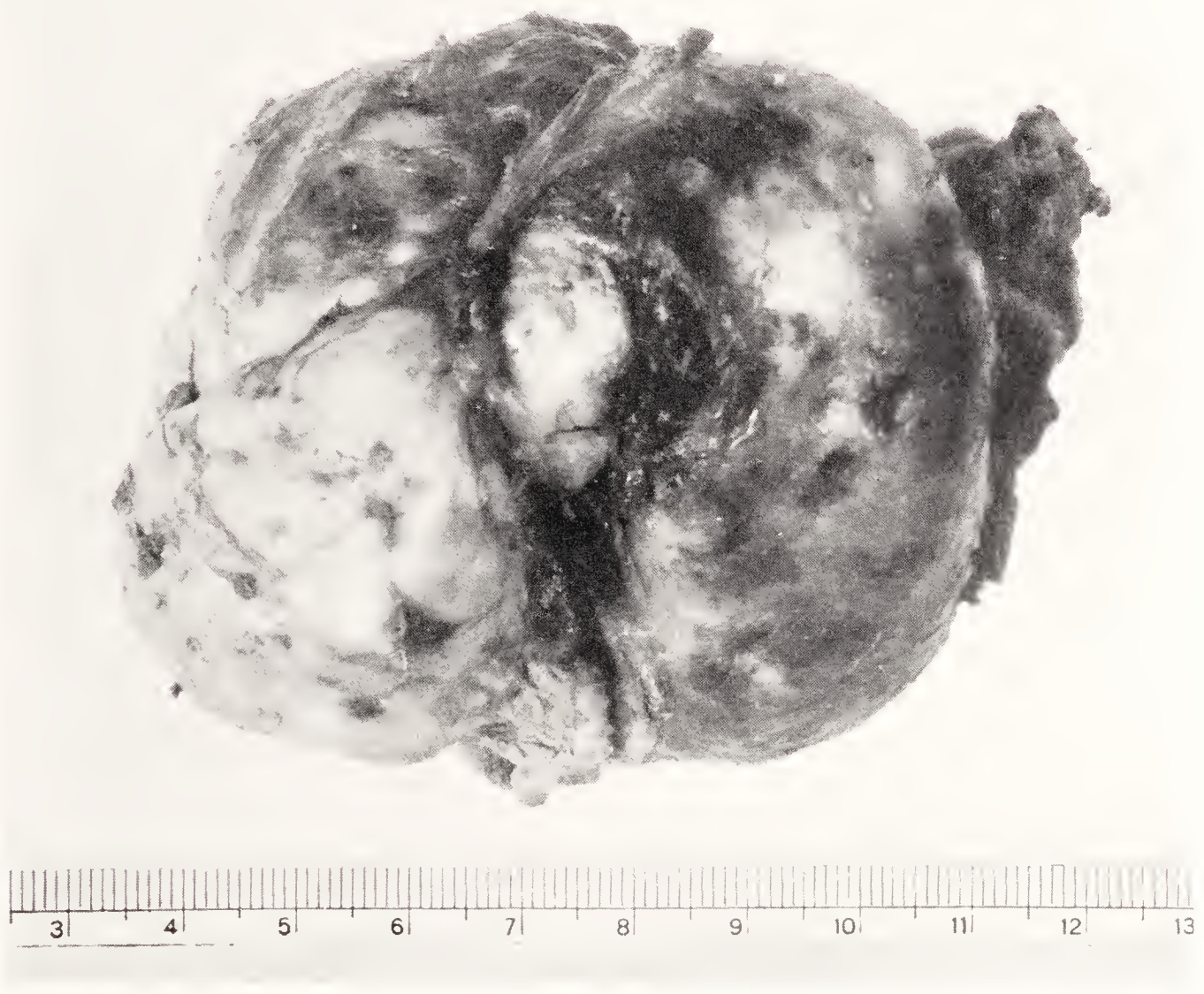


FIG. 70. The rapidly recurrent growth removed 8 months later from same situation as tumour shown in Fig. 67.

been removed—the combined weight of tissue exceeding the total weight of a normal adult brain. On one occasion alone the enucleated mass weighed 430 grams. Each time we have felt reasonably convinced that the enucleation had been complete.

It can be gathered from this that operations for recurrences are common, a fact which must be taken into account in the mortality percentages. In one of my early cases a 180-gram "benign psammoma" had supposedly been removed in its entirety. After twelve years of perfect health unmistakable signs of recurrence began to appear but they were ignored by the patient who did not report until five years later when the

recurrent growth had become so large (250 grams) a fatality occurred from escape of blood into the ventricles during its removal.

A complete report on the meningiomas in our series, with the purpose of pointing out the various syndromes they produce in their more favoured sites of origin, is in course of preparation. Those arising from the olfactory groove,[53] those from the tuberculum sellae[54] and the peculiar tumours of the temporal fossa[55] which are particularly prone to produce hyperostoses of the bone have already been briefly described. Until the task of covering the whole subject is completed, precise mortality figures for the several groups are scarcely worth attempting to determine.

Statistics.—Of the 271 recorded cases, 260 have been operated upon 489 times with 54 deaths, giving a case-mortality of 20.8 per cent and an operative mortality of 11.0 per cent. The 69 new cases during the last three-year interval, for which electro-surgical methods have been available,[56] have had 103 operations with 8 fatalities, giving a present day 11.6 per cent case-mortality and a 7.7 per cent operative mortality.

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[53] The meningiomas arising from the olfactory groove and their removal by the aid of electro-surgery. Lancet (Lond.), 1927, I, 1329–1339.

[54] Cushing and Eisenhardt. Meningiomas arising from the tuberculum sellae: with the syndrome of primary optic atrophy and bitemporal field defects combined with a normal sella turcica in a middle-aged person. Arch. Ophth., 1929, I, 1–41, 168–205.

[55] The cranial hyperostoses produced by meningeal endotheliomas. Arch. Neurol. & Psychiat., 1922, VIII, 139–152.

[56] Electro-surgery as an aid to the removal of intracranial tumors. Surg. Gynec. & Obst., 1928, XLVII, 751–784.

IV. The Acoustic Tumours

In a monograph on the subject of these lesions published fourteen years ago[57] reasons were given for the adoption of the simple term "acoustic tumour," as being anatomically more precise than cerebello-pontile tumour; for in the cerebello-pontile recess other tumours than those arising from the acoustic nerve are not infrequent. It was preferable to the histological misnomers such as endothelioma, sarcoma, fibroma, glio-fibroma, etc., which had been given to acoustic tumours; and though the designation acoustic neurinoma of Verocay was not open to this objection, it was misleading, for the tumours probably contain no neuroglial elements, and was scarcely necessary as all of them have an identical structure. The more modern designation—perineural fibroblastoma[58] of the acoustic nerve—introduced by Mallory—while histologically correct is unnecessarily cumbersome for every-day parlance.

From a symptomatic and diagnostic standpoint there is little to add to the description of these tumours written many years ago. Given an accurate and dependable chronology of symptoms, they are probably the most easily diagnosed of all intracranial neoplasms. Only when the anamnesis is faulty or undependable are they likely to be mistaken for other tumours of the cerebello-pontile recess.

Papillomas which take their origin from the choroid plexus at the foramen of Luschka, slow-growing gliomas of the lateral pons which early in their course involve the acoustic nucleus,[59] meningiomas which arise in the vicinity of the porus acusticus, and cholesteatomas of the recess (*cf.* page 101) may cause symptoms which closely simulate an acoustic tumour and may lead to an erroneous preoperative diagnosis. We never happen to have seen a case with bilateral tumours which must be exceedingly rare,* though Gardner and Frazier have recently described in a family, they have had an opportunity to study, a remarkable hereditary tendency in this direction.

A loss of the vestibular response to caloric (Barany) tests is an early objective sign which precedes complete loss of hearing. This suggests that the favoured point of origin of the tumours is in the vestibular division of the nerve. The tumours, moreover, so far as is known, originate in that portion of the nerve which lies within the porus acusticus and since they

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[57] Tumors of the nervus acusticus and the syndrome of the cerebellopontile angle. W. B. Saunders Co., Phila., 1917.

[58] *Cf.* Rhoads, C. P., and Van Wagenen, W. P. Observations on the histology of the tumors of the nervus acusticus. Am. J. Path., 1928, IV, 145–151.

[59] Horrax, G., and Buckley, R. C. A clinical study of the differentiation of certain pontile tumors from acoustic tumors. Arch. Neurol. & Psychiat., 1930, XXIV, 1217–1230.

* Since this writing one of these cases with bilateral acoustic tumours and multiple meningiomata has come under observation and been successfully operated upon, both acoustic tumours having been enucleated at separate sessions.

have an obvious relation to von Recklinghausen's disease, in which multiple lesions of essentially the same histological nature occur, they are doubtless of similar congenital origin.

I ventured to state in my 1917 monograph that, since these tumours were so common, serial sections of a sufficient number of acoustic nerves would be likely to reveal their microscopic point of origin. My former

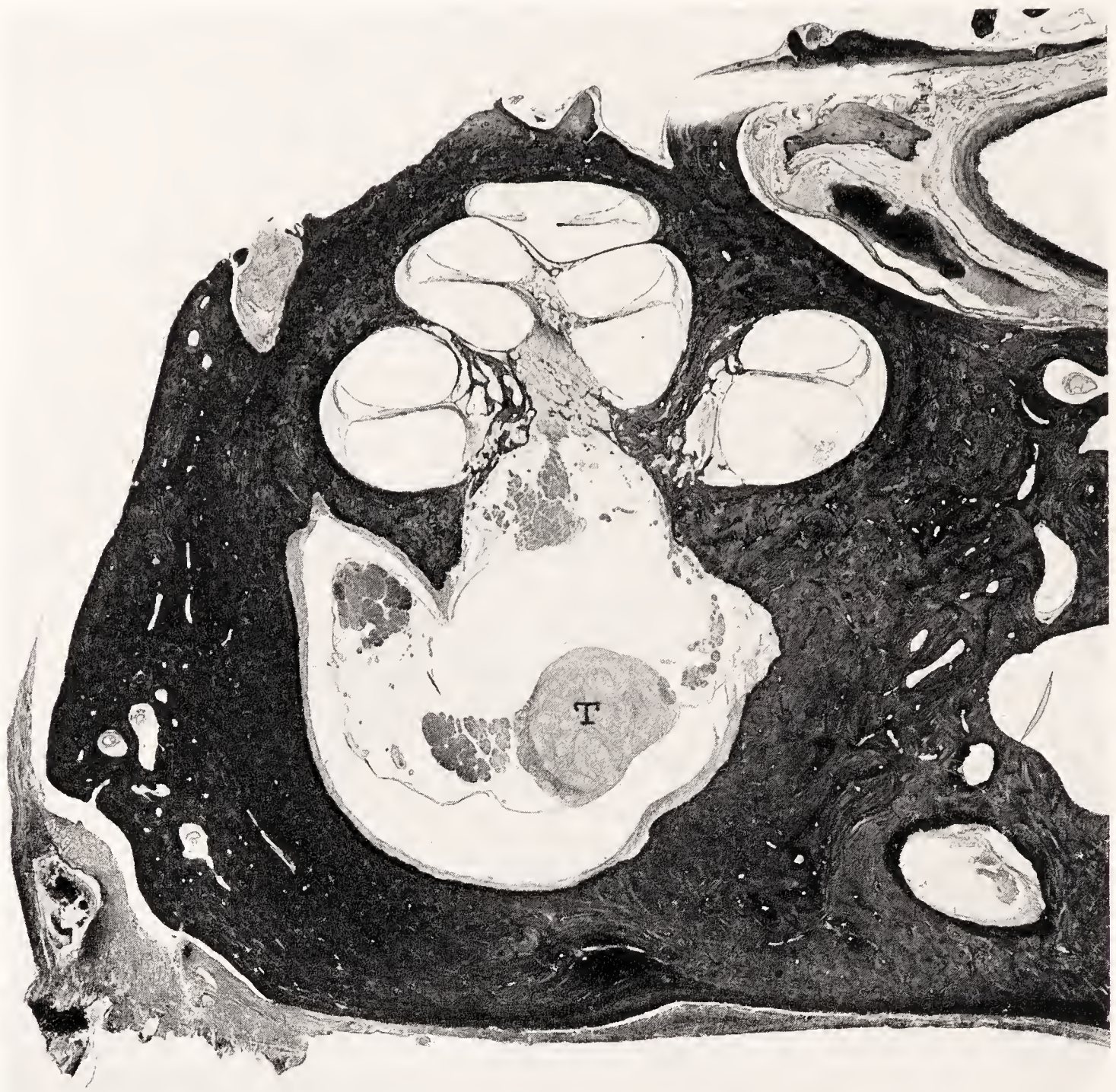

FIG. 71. Dr. Crowe's case of minute acoustic neurinoma (T) encountered in routine examination of temporal bones of patients whose auditory functions had been previously tested, the tests having proved normal in this case (mag. ×8).

associate, Prof. S. J. Crowe of the Johns Hopkins Hospital, in his exhaustive study of the middle ear and its disorders has come upon such a lesion and has kindly given me the privilege of reporting the case.

A negro, aged 30, with advanced syphilitic aortitis and hypertension died in hospital from this disorder and came to autopsy.

He was known, from ante mortem clinical studies to have had normal hear-

ing for whispers and watch. Tuning forks (128, 256, 512 and 2048 double vibrations per second) were heard normally. Air conduction was better than bone conduction. Weber's test was not lateralized. Vestibular tests were not made because of his general condition, but there was no spontaneous nystagmus. The audiometer showed normal perception of all tones from 332 to 16384 d.v.

There was no reason to suspect any abnormality of the auditory apparatus during life and the minute lesion was overlooked both at the autopsy and later in Dr. Crowe's laboratory where the temporal bones were grossly described. Not until the routine sections of the petrous bone were cut was the tiny growth deep in the porus acusticus brought to view (Figs. 71, 72).

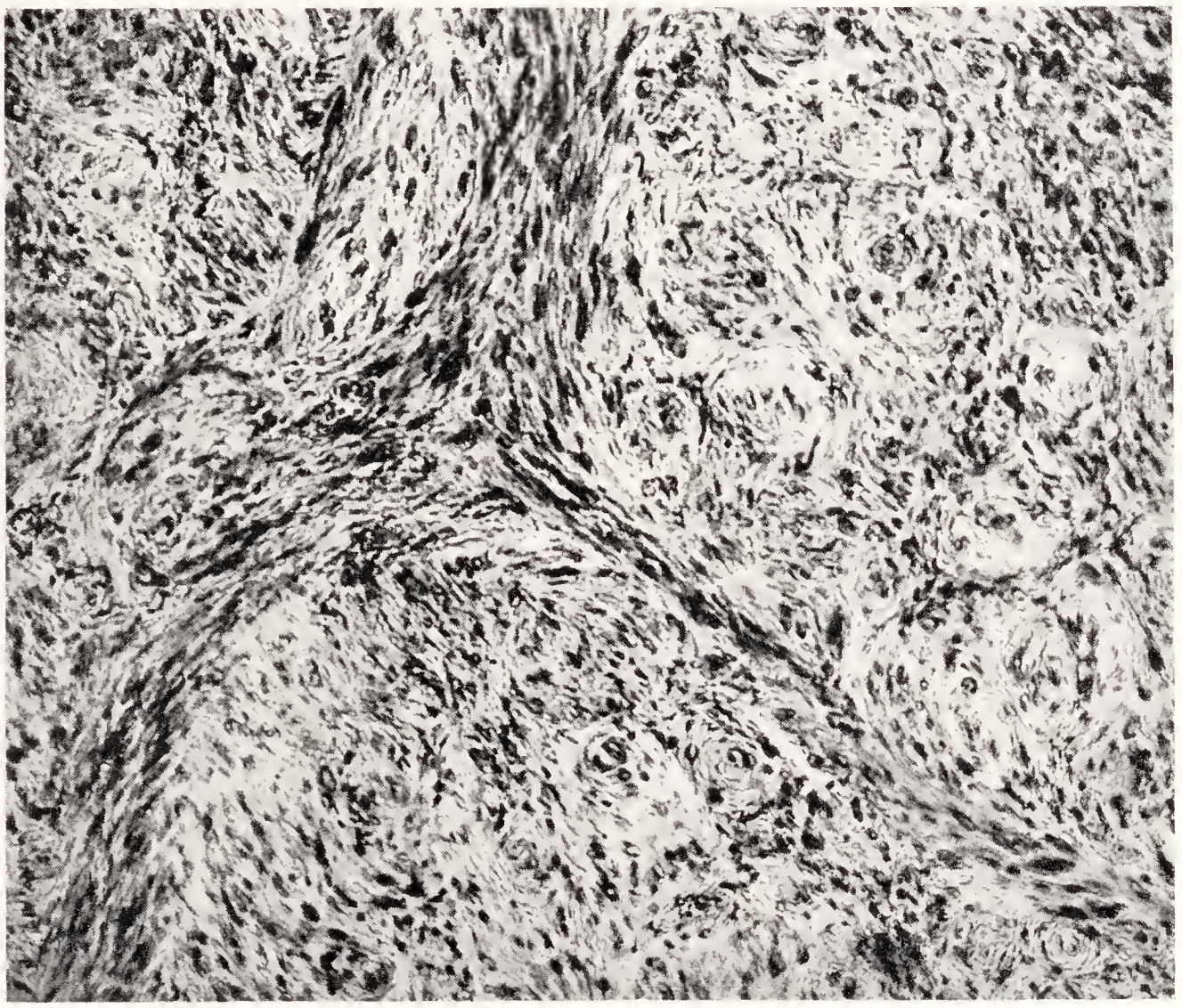

FIG. 72. Photomicrograph (hematoxylin and eosin, ×150) of the minute, asymptomatic, acoustic tumour, shown in Fig. 71.

So far as our clinical experience goes, patients with large acoustic tumours may still retain some hearing, but the vestibular responses to caloric tests are invariably abolished. The presumable origin of these tumours in the vestibular nerve appears, therefore, to be substantiated. What is more, caloric responses are never regained after operation even though an occasional patient may show a slight postoperative improvement in hearing. This may be explained by the fact that the greatly stretched acoustic fibres appear to be distributed circumferentially beneath the capsule rather than to traverse the body of the tumour,[60] so

[60] Morelle, J. Tumors of the acoustic nerve. Arch. Surg., 1929, XVIII, 1886–1895.

that on the release of tension following a subcapsular enucleation they occasionally tend to regain a certain degree of function.

From a neurosurgical standpoint the proper treatment of these tumours is admittedly still in a debatable state. Since they are benign lesions, their total enucleation would be the ideal procedure. This in earlier days was customarily attempted with the staggering operative mortality of from 60 to 75 per cent, which few patients or surgeons would be willing to face. Owing to the recurrence of symptoms which follow incomplete operations, Dandy has again (1925) advocated total removal in all cases at the primary session, and, supported by the present-day improvements in operative technique, others incline to follow his lead.

Whether a total extirpation should be attempted in all cases is a matter on which surgeons are likely to disagree, and one on which each surgeon is likely to change his opinion from time to time. In six cases in the series what I have called a near total extirpation has been carried out. The first time this was done (Case 55 in the series) was in 1921, the tumour having been largely replaced by a cyst with a sufficiently tough capsule to permit it to be dislodged and drawn out intact without undue difficulty.

Since then, five others, most of them partly cystic lesions, have been similarly treated though the stalk of the growth in the porus acusticus has necessarily been left behind as a possible sprouting point of recurrence. In the greater number of tumours, however, the capsule is vascular, thin and friable; and added to this difficulty a strictly total extirpation necessitates not only the cleaning out of the porus, which may be a difficult and bloody procedure, but also the removal of the portion of the capsule adjacent to the pons, which is highly precarious. I have repeatedly, in years gone by, after a series of favourable cases, some of them with near total extirpations, suddenly been confronted by a fatality from being overradical and have then dropped back to a more conservative attitude, only to have the same cycle repeated.

In the average case, if the pressure effects of the tumour can be so far overcome by an intracapsular excavation as to permit a subsidence of the choked disc and thus to save vision, one may well be content; and should a secondary operation for recurrence ever be necessary, it need not be particularly dreaded. An example of this is shown by the fifth patient in the series:

At the operation in *May 1909* (J. H. H. Surgical No. 24119), the central subcapsular mass of the growth was enucleated with such satisfactory result that the case was reported a year later by M. Allen Starr as the only actual recovery from an operation for cerebellar tumour in his experience.* In *1912*, owing to a recurrence of symptoms which coincided with a pregnancy, she was

* Among all contemporary neurologists, Dr. Starr was possibly the most insistent upon operations as the only hope for tumours of the brain; but as matters stood up to 1910, it had been a most discouraging business, particularly as regards tumours of the cerebellum. This can be gathered from his paper in which the literature of the subject had been brought up to date including his own thirteen cases (Am. J. M. Sc., 1910, XXXIX, 551–581).

again operated upon, the same procedure as before being repeated. Almost twenty years have now elapsed and she remains in excellent health, goes everywhere, manages her own affairs, and is quite content with her lot.

In recent years the technical features of this procedure have been vastly improved. The chief elements in its progressive development in my estimation have been: (1) The substitution, following de Martel's example, of local anaesthesia (eked out if necessary by tribromethanol per

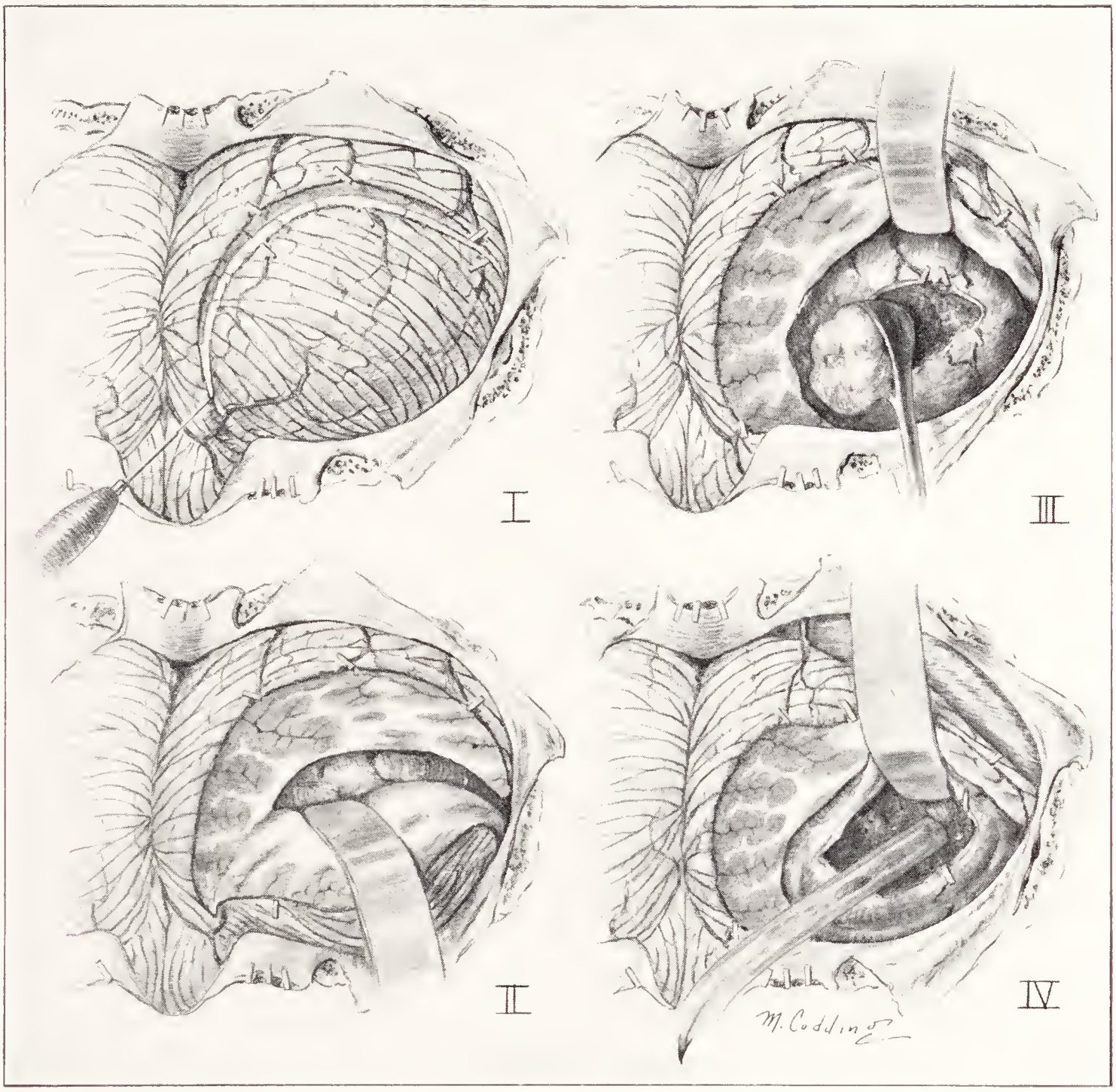

FIG. 73. Operative sketches of the routine procedure in most present-day cerebellar operations for acoustic neurinoma.

rectum) to replace inhalation narcosis by ether; (2) The employment of suction to supplement the intracapsular spooning out of the lesion; (3) Electro-surgical devices as an aid to haemostasis; and (4) The new principle of cerebellar "uncapping." Of all these devices, which have not only facilitated the operations but made them more safe, the last I believe is the most important. On January 21, 1928, I was forced to take this step for the first time under the following circumstances:

The patient (Surgical No. 30497) had been admitted to hospital with a highly advanced acoustic syndrome—bedridden, nearly blind, dysarthric and dysphagic. He was incoöperative and restless under the operation and during its course we were finally obliged to administer ether. This increased the respiratory difficulties, already present, and though the tumour was exposed and partially excavated, the patient's condition made it necessary to withdraw in the hope that he might gain sufficient relief from the decompression to permit a secondary operation at a more favourable time.

Owing to continued respiratory embarrassment with increasing cyanosis, in desperation the wound was reopened after an hour's interval. The cerebellum overlying the growth was found to be so greatly swollen and injected it was thought necessary to sacrifice it and its outer two-thirds were electrically removed. This manoeuvre so effectually uncovered the tumour that it was newly attacked until the excavation reached the point of allowing the entire capsule to collapse. The patient's embarrassed respiration was immediately relieved and he made a good recovery.

What chiefly surprised us was the absence of any more marked ataxia in the corresponding hand and arm than on the opposite side, as a consequence of the partial ablation of the hemisphere.

Since this experience we have similarly "uncapped" the tumour by removing the overlying shell of cerebellum (Figs. 73, 74) in the majority of the subsequent cases. There have been no fatalities when this has been done, though in many instances the operation has been no less desperate than the one just described owing to a highly advanced syndrome. In only one patient following a secondary operation for recurrence has there been an increase in ataxia, presumably due in this instance to damage of the dentate nucleus.

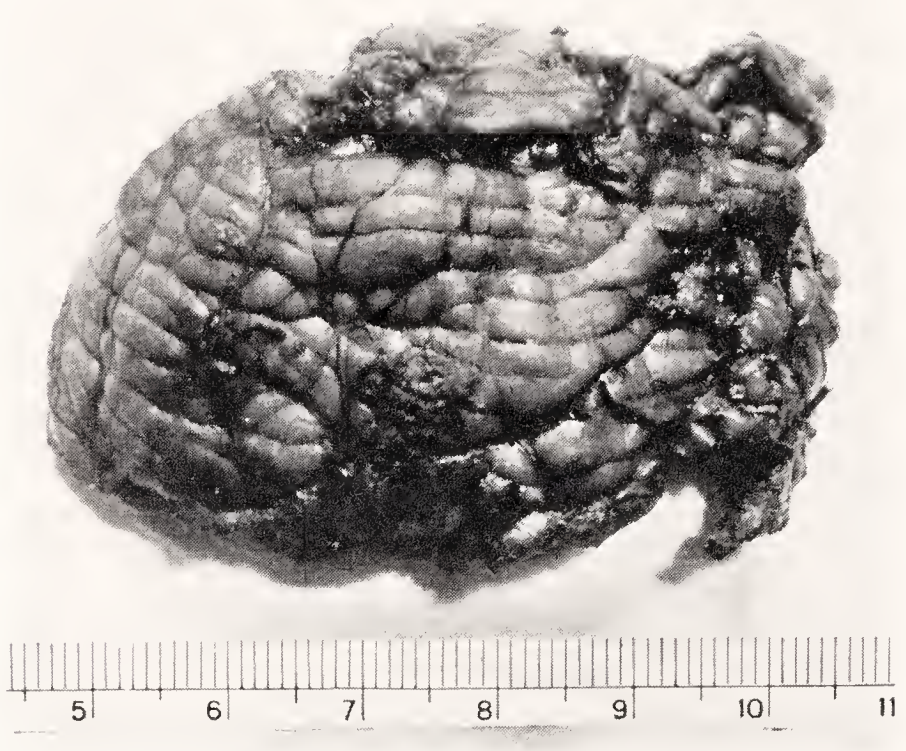

FIG. 74. Specimen (nat. size) showing average amount of cerebellar hemisphere removed in process of "uncapping" an acoustic tumour.

Naturally in all of these operations the attempt has been made so thoroughly to remove the intracapsular portion of the growth that its walls may be drawn together until they collapse into the cavity where they may be puckered by the coagulating current. In some instances a considerable portion of the loose and empty capsule has been removed as well, but to do this completely inevitably leads to a permanent facial paralysis. This is one of the chief drawbacks to a total or near total extirpation, for it is a complication highly annoying both to

patient and surgeon. And should the trigeminal nerve have been injured at the same time so that the safety of the eye is jeopardized, it may not be saved even by a long drawn out hospital sojourn behind a Buller shield, and after a spino-facial anastomosis.

Operative Statistics.—In my monograph on these tumours (1917) after citing the case-mortality which had been reported from a number of European clinics, this statement was made (page 274):

> Shocking as these figures are and desperate as the condition must be which justifies operations attended with such high risks, it must be acknowledged that they represent the experience of surgeons who at the time of their report had had but few cases and whose later records would have been far better. After the first operation the surgical mortality in the writer's series was 100 per cent; after the next 10 cases it was lowered to 40 per cent, after 15 cases it had dropped to 33.3 per cent; after 20 cases to 30 per cent, after 25 cases to 24 per cent, and after 30 cases to 20 per cent; and it must continue to fall until it drops to 10 or 5 per cent or better, even though one's total figures must carry the burden of early inexperience.

In a later note,[61] statistics were given for the 48 cases observed up to January 1, 1921, in which there were 64 operations and 9 postoperative

TABLE III

SHOWING CASE-MORTALITY PERCENTAGES FOR ACOUSTIC TUMOURS IN SUCCESSIVE GROUPS OF FIFTY

Dates	Time Interval	Number Cases	Number Oper'ns	Number Deaths	Case-Mortal.	Op'e Mortal.
					per cent	per cent
1/18/1906–10/ 5/1915	9 yrs. 9 mos.	21	32	6	28.6	18.7
1/22/1916– 2/13/1923	7 yrs. 1 mo.	50	64	10	20.0	15.6
3/ 6/1923– 9/ 6/1927	4 yrs. 6 mos.	50	62	7	14.0	11.3
10/18/1927– 7/ 1/1931	3 yrs. 9 mos.	50	58	2	4.0	3.4

fatalities; an 18 per cent case-mortality and a 14 per cent operative mortality. Although conscious of the fact that the operative percentage was falling, these figures have not again been assembled until the present time when the matter was taken up by Dr. Carl List. The total figures to July 1931 comprise 176 tumours of which 171 have been operated upon 219 times with 25 postoperative fatalities, a 14.6 per cent case-mortality and an 11.4 per cent operative mortality. Dr. List has found that the 123 additional cases observed in the ten years since 1921 have been operated upon 159 times with a 13.0 per cent case-mortality and a 10.1 per cent operative mortality.

[61] Further concerning the acoustic neuromas. Laryngoscope, 1921, xxxi, 209–228.

But still more important than these slightly improved percentages for the past decade, compared with those preceding it, is the fact that in the last 50 cases in all but 12 of which the tumour was uncapped before removal, there have been only two fatalities, giving a 4.0 per cent case-mortality. One of these fatalities was in a patient brought to hospital in coma and operated upon as an emergency under artificial respiration because of respiratory failure in the ward. The other fatality occurred on the third day from pneumonia in a case in which the cerebellum had not been uncapped and the operation because of peculiar difficulties was left incomplete. In Table III on the preceeding page the progressive improvement in the mortality percentages is particularly apparent.

V. Congenital Tumours

Under this caption are included those lesions which on the Cohnheim basis obviously arise from some cell-inclusion (*anlage*) in early embryonic life. Other tumours which in all probability, but with less certainty, are likewise ascribable to some developmental "fault" (the acoustic tumours and the cerebellar medulloblastomas, for example) are considered elsewhere. The group as it stands includes 92 craniopharyngiomas, 15 cholesteatomas and dermoids, and 6 chordomas and teratomas. Of these several subgroups, the only one which is of major surgical importance is the first.

THE CRANIOPHARYNGIOMAS

This admittedly somewhat cumbersome term has been employed, for want of something more brief, to include the kaleidoscopic tumours, solid and cystic, which take their origin from epithelial rests ascribable to an imperfect closure of the hypophysial or craniopharyngeal duct.[62] From a developmental standpoint they are variously called hypophysial-duct tumours, craniopharyngial-duct tumours, and Rathke's-pouch tumours; from an anatomical basis, interpeduncular or suprasellar cysts; and from a histopathological basis, adamantinomas, which is still more unfortunate. They may vary from delicate pea-sized, thin-walled cysts to multilocular cystic structures of great diversity which may attain an amazing size; their epithelial-lined walls tend to undergo proliferation, keratinization,[63] and deposition of lime salts until, in some instances, a solid calcified mass as large as a tennis ball may be roentgenologically disclosed in the centre of the brain.

Since scarcely any two are precisely alike and since those of similar size and character show such differences of behaviour, the course of any given tumour is impossible to foretell. Though the date of hospital admission is of approximate value only in estimating the time of symptomatic onset, the patients' ages by decades have been 14 for the first (the youngest, $3\frac{1}{2}$ years), 29 for the second, 19 for the third, 13 for the fourth, 9 for the fifth, 6 for the sixth decade, and two of the patients have been over 60 years of age when symptoms had shortly before first put in their appearance. It is evident from this that the lesions may long remain small and wholly silent. What stirs them into activity is not apparent though a history of preceding trauma is surprisingly common.

From a symptomatic standpoint, as can be readily understood, lesions which differ so greatly in their gross features can produce a multitude of

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[62] McLean, A. J. Die Craniopharyngealtaschentumoren (Embryologie, Histologie, Diagnose und Therapie). Ztschr. f. d. ges. Neurol. u. Psychiat., 1930, CXXVI, 639–682.

[63] Bailey, P. Note concerning keratin and keratohyalin in tumors of the hypophysial duct. Ann. Surg., 1921, LXXIV, 501–505.

symptoms of the greatest variety. This is due to a number of causes, principal among which are: (1) disturbances of pituitary function; (2) pressure involvement of optic nerves and chiasm; (3) stimulation or paralysis of important hypothalamic centres controlling the vegetative nervous system; and finally (4) hydrocephalus from occlusion of the foramina of Monro. Consequently, depending upon the age of onset, as well as upon the rapidity and extent of the growth, patients may be sexually-infantile dwarfs or show varying grades of adiposo-genital dystrophy. They are apt to have disturbance of vision due to primary optic atrophy with bitemporal field defects advancing to blindness. Diabetes insipidus, nutritional disorders such as adiposity or emaciation, somnolence, thermoregulatory disturbances, and other diencephalic symptoms are common. And finally headaches betraying the onset of hydrocephalus with its attendant increase of intracranial tension (without choked discs except in rare instances) commonly occur before the end.

Since we first began to detect and realize the importance of suprasellar shadows on X-ray plates,[64] it has been shown that 80 per cent of the cases have detectable shadows of intra- or suprasellar calcification;[65] and though other lesions in this region may produce misleading shadows[66] of calcification, they are far less common than are the tumours under consideration. The pituitary fossa itself is apt to be somewhat malformed without definite enlargement, though it may become expanded when the tumour arises primarily within the sella and remains confined there by an intact diaphragma.

All this has now slowly become familiar not only to neurosurgeons but to the profession at large. Twenty years ago when my pituitary monograph was in course of preparation, my experience was limited to two examples and both of these were disclosed post mortem. The nature of the lesions was then so poorly understood they were, like other pituitary tumours, thought capable of being attacked by a transphenoidal operation. As chance would have it, one of the early cases in the series happened to be an intrasellar craniopharyngioma with an expanded sella. The story follows:

A young man 19 years of age entered the Johns Hopkins Hospital (Surgical No. 28986) in *December 1911*, complaining of loss of vision. In addition to slight evidence of "dyspituitarism" he was found to have pallor of the optic nerves, bitemporal field defects, and an enlarged sella containing shadows of calcification.

On *January 4, 1912*, by the transphenoidal route a cyst containing motor-oil-coloured fluid rich in cholesterin crystals was evacuated. A cerebrospinal fluid leak resulted with a severe meningitis from which he luckily recovered.

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[64] Luger, A. Zur Kenntnis der im Röntgenbild sichtbaren Hirntumoren mit besonderer Berücksichtigung der Hypophysengangsgeschwülste. Fortschr. a. d. Geb. d. Röntgenstrahlen, 1914, XXI, 605–614.

[65] McKenzie, K. G., and Sosman, M. C. The roentgenological diagnosis of craniopharyngeal pouch tumours. Am. J. Roentgenol., 1924, XI, 171–176.

[66] *Cf.* The chiasmal syndrome of primary optic atrophy and bitemporal field defects in adult patients with a normal sella turcica. Trans. XIIIth Internat. Ophth. Congress, Amsterdam, 1929, 97–184.

Practically normal vision was regained after the operation and held good for nearly ten years when, in *December 1923,* a transfrontal operation was performed in the Brigham Hospital exposing a typical "craniopharyngeal pouch cyst" which was again evacuated and a portion of the wall removed for histological verification. An uneventful recovery followed this operation, and at the present time, *July 30, 1931*, nearly 20 years since his primary operation, he has normal visual acuity, remains well and is self-supporting.

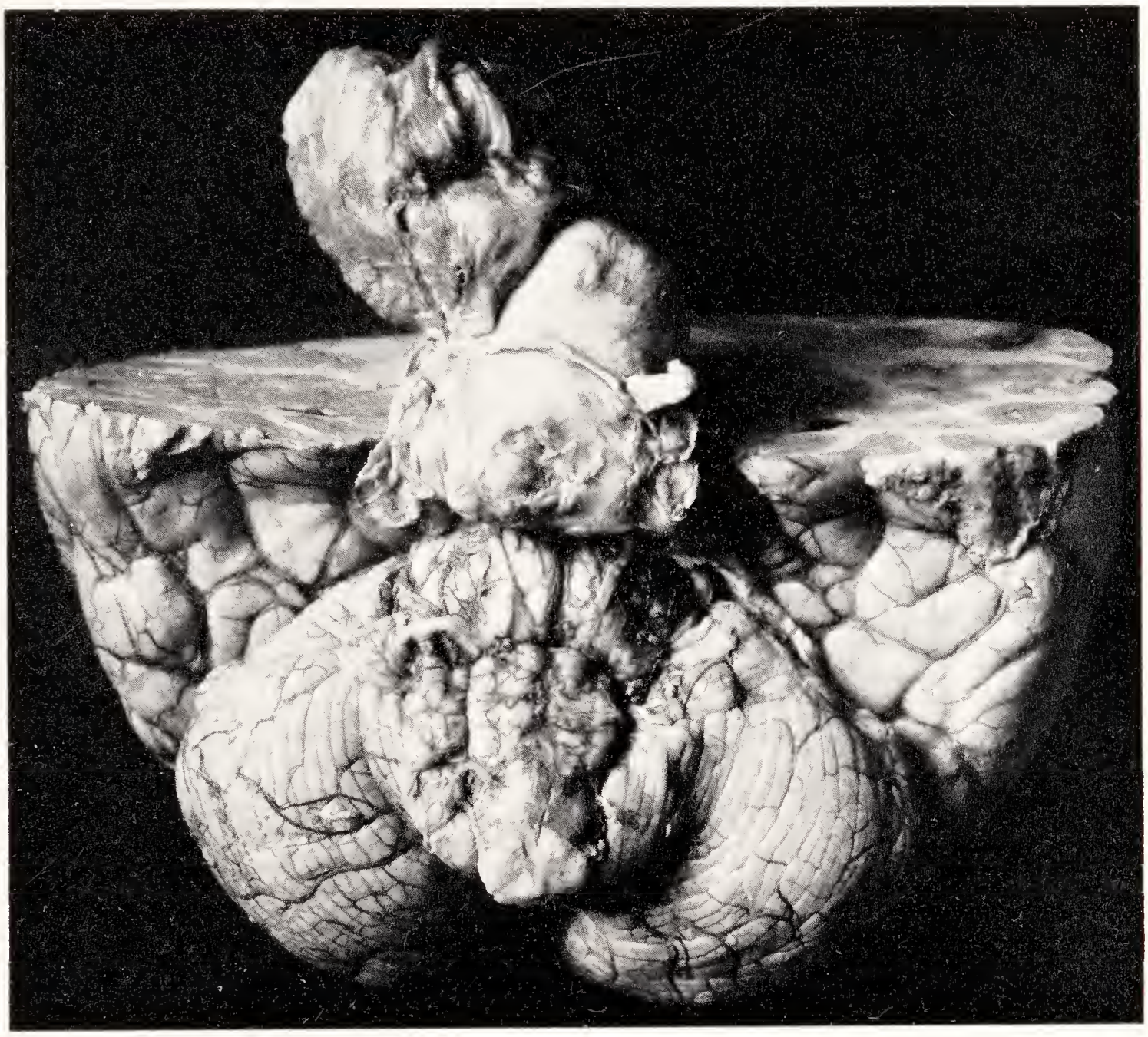

FIG. 75. To show the intracranial extension of a primarily intrasellar craniopharyngioma operated upon from below owing to a mistaken diagnosis of adenoma.

This was a highly misleading experience which largely accounts for the fact that 14 of the cases in the series have been verified by the transphenoidal route. Even as late as 1925, one patient was operated upon by this method owing to a mistaken diagnosis, as follows:

A man, 26 years of age (Surgical No. 25383), entered the hospital because of headaches and serious impairment of vision to near blindness. He had an advanced primary atrophy and a widely distended sella. In the absence of suprasellar calcification, a diagnosis of pituitary adenoma was made and as the sphenoidal region appeared to be involved a transphenoidal procedure was advised.

At the operation, *December 14, 1925*, the sphenoidal cells were found to be filled with a soft tumour supposedly adenomatous which was thoroughly excavated and the contents of the sella itself were also cleaned out as completely as possible. The tumour proved to be a craniopharyngioma.

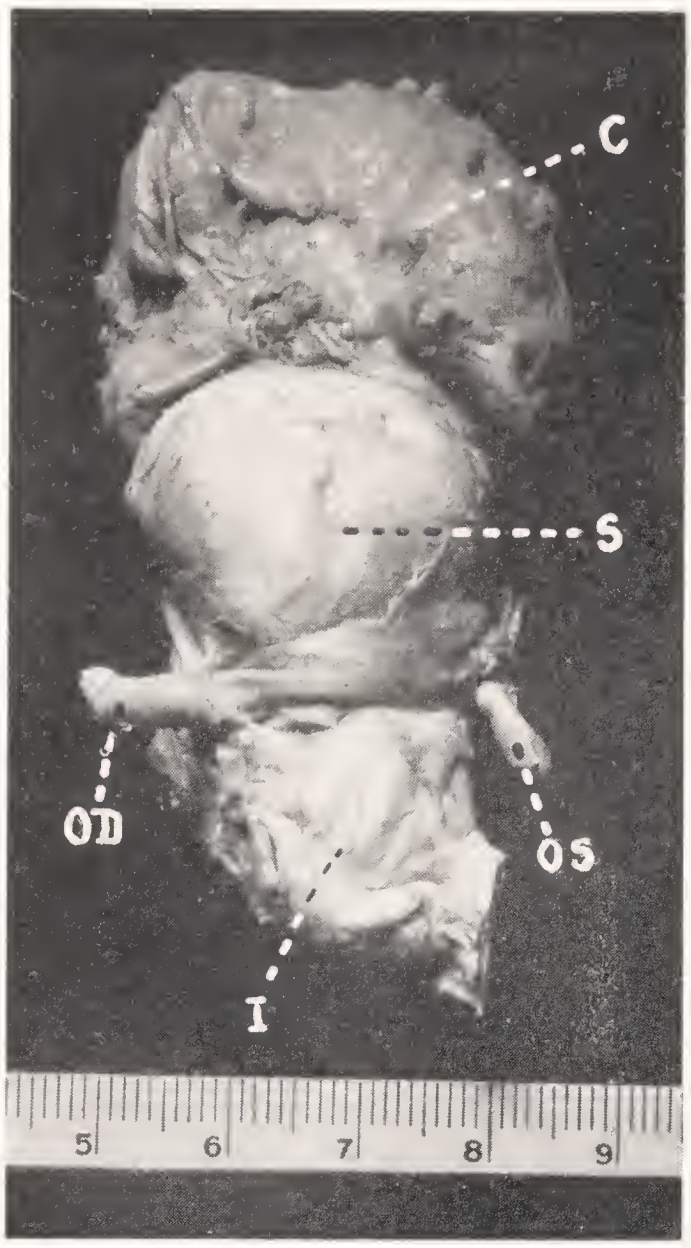

FIG. 76. The same tumour as in Fig. 75, detached to show its relation to stretched chiasm and optic nerves. O.D., right optic nerve. O.S., left optic nerve. I., intrasellar portion of tumour. S., suprasellar expansion of same. C., superimposed cyst.

There was very little change in the patient's condition at the time of his discharge.

On *February 8, 1926*, he went to bed with complaint of a headache and a local physician gave him a hypodermic of morphia from which he never awoke. The brain was removed and forwarded to us for study. The solid tumour (Figs. 75, 76) was dissected out of its bed the better to study the deformation of the chiasm and nerves.[67]

Here was an essentially solid epithelial tumour, a hopeless surgical problem from the outset; and even had the growth been exposed secondarily from above, little if anything could have been accomplished. The more essentially cystic lesions are naturally more favourable. But even these when evacuated and partially removed tend quickly to reform or refill; and after temporarily brilliant results (so far as concerns improvement of vision) at a secondary operation the lesion not infrequently will be found replaced by a solid calcareous growth. The attempt to remove such a mass, if not immediately fatal, is apt to precipitate a serious diabetes insipidus or greatly to exaggerate the pre-existing symptoms of the disorder. An example of this has been given in my recent Lister lecture.[68]

One would expect these congenital epithelial tumours to be capable of enucleation like dermoid cysts elsewhere in the body, but they so definitely adhere to the adjacent structures neighbouring on their place of origin, it is rarely possible to shell them out of their bed without the production of serious secondary symptoms. To be sure, one may occasionally succeed in stripping out a thin-walled cyst and examples of this have been

[67] Walker and Cushing. Studies of optic-nerve atrophy in association with chiasmal lesions. Arch. Ophth., 1916, XLV, 407–437.

[68] Neurohypophysial mechanisms from a clinical standpoint. Lancet (Lond.), July, 1930 (Case pg. 183).

reported;[69] but when the tumour is partly solidified and calcareous, sad experience warns the surgeon to leave it pretty much alone. All this accounts for the fact that our series of unverified tumours contains a considerable number of clinically unmistakable craniopharyngiomas which have not been operated upon.

The clinical histories of the 92 verified cases contain some most bizarre stories: of foolishly attempted extirpations of tumours intact; of partial enucleation of huge cystic intracranial expansions of the lesions by transcortical procedures; of tiny pellucid cysts that could be peeled out from under the chiasm; of patients kept going for years by the repeated tapping of large cysts. But all in all, these cases offer the most baffling problem which confronts the neurosurgeon; and the fact that the mortality which accompanies radical attempts to extirpate a large solidified tumour (Fig. 77) must approximate 100 per cent probably accounts for the few reports of these lesions other than by pathologists. Even from the mere standpoint of preservation of vision[70] the problem is a highly complicated and difficult one. Until some method is devised whereby the usually multilocular epithelial lesion can be destroyed or inactivated *in situ* (*cf.* Fig. 78), the mortality will doubtless remain high.

FIG. 77. Craniopharyngioma extirpated intact in 1913 with prompt fatality (calcareous portion on right; cystic portion on left).

Statistics.—Owing to sudden death or other reason five of the 92 cases in the series have been verified at autopsy without preliminary operative intervention. The 87 remaining cases have been subjected to 130 operations as follows: subfrontal osteoplastic exposure, 90; transphenoidal exposure, 14; lateral osteoplastic flap with transcortical or transventricular or transcallosal exposure of lesion, 12; temporizing subtemporal decompression, 9; and in 5 instances a suboccipital exploration on mistaken localising diagnosis.

Nineteen of the 87 patients succumbed after a total of 130 operations (7 after the first, 9 after a second, 2 after a third and 1 after a fourth pro-

[69] *Cf.* Les Syndromes hypophysaires au point de vue chirurgical. Rev. neurol., 1922, XXXVIII, 779–808.

[70] *Cf.* The chiasmal syndrome etc. Arch. Ophth., 1930, III, 505–551, 704–735.

cedure), giving a 21.8 per cent case-mortality for the whole series and a 14.6 per cent operative mortality. For the recent three-year period (1928–1931), there have been only 14 of these lesions surgically verified 19 times with 3 fatalities, giving essentially the same mortality percentages, viz., a 21.4 per cent case-mortality and 15.8 per cent operative mortality.

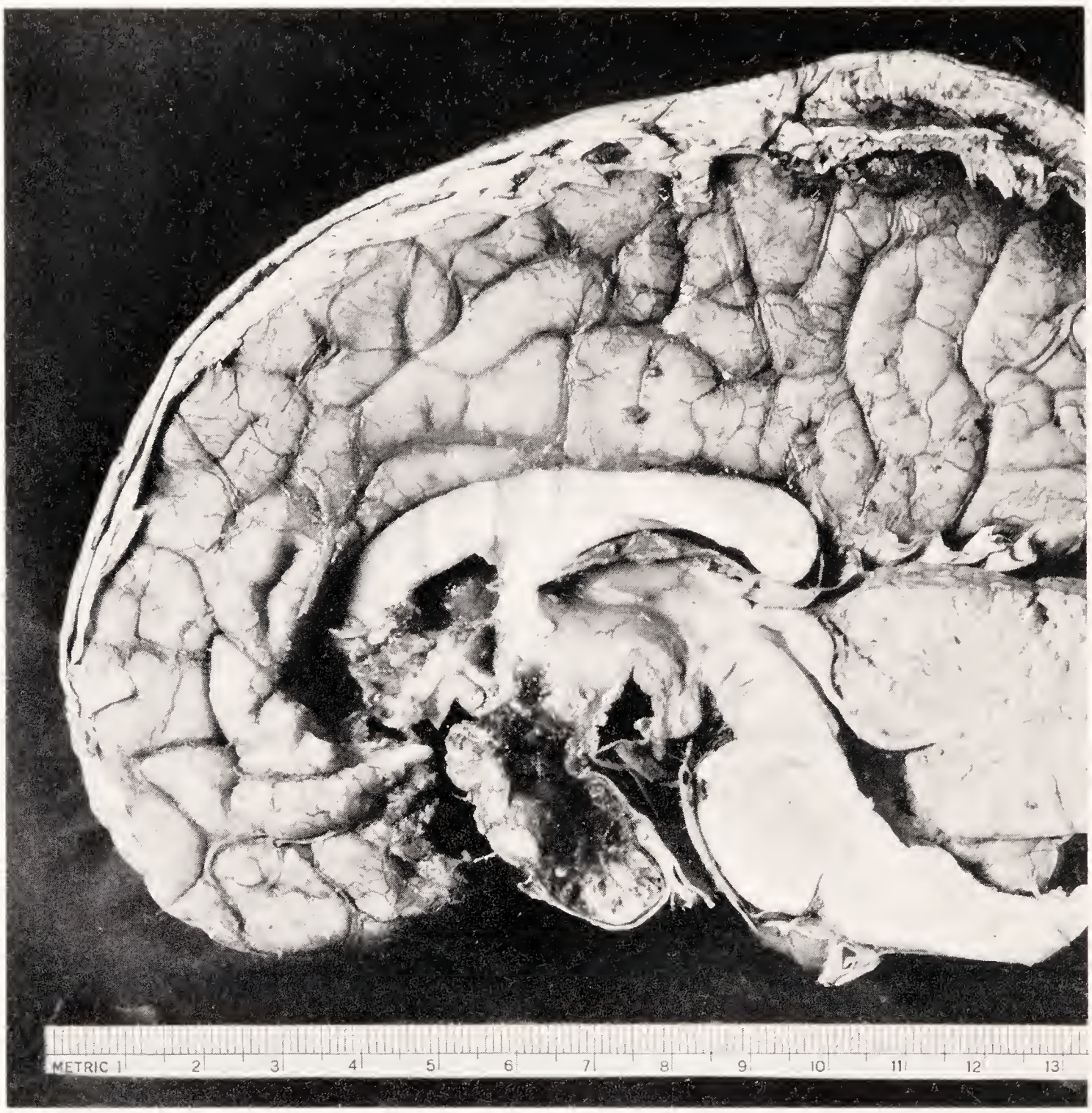

FIG. 78. Specimen showing multilocular tumour residual after surgical extirpation by right transcortical approach of large cystic expansion into frontal lobe. Early postoperative fatality (Surgical No. 38556).

CHOLESTEATOMAS AND DERMOIDS

Only 15 examples of these rare tumours occur in the series, all but three of them being of the type described by Cruveilhier a century ago as "pearly tumours"—an apt description for the glistening surface of the outer membrane has an unmistakable mother-of-pearl appearance. They

arise from embryonic inclusions of the epiblast and supposedly, in accordance with the period at which the cellular anlage has been shut off, the capsule of the lesion may be purely epidermal or dermal, in which latter case it may even contain hair-producing follicles.

The tumours vary greatly in their situation, as may be gathered from the three papers on the subject which ten years ago emanated from the clinic. Examples of a mid-cerebellar and a suprasellar lesion were reported by Dr. Bailey;[71] hair-containing tumours (temporal lobe 2, and fourth ventricle 1) were reported by Dr. Horrax;[72] and the writer described[73] a large diploetic cholesteatoma of which rare type we have recently met with still another example.

Two or three of the tumours, clinically mistaken for acoustic tumours, have been disclosed in the lateral recess. In one instance an irregular sac extended alongside the brain stem from pituitary fossa to foramen magnum crowding its way into every crevice. The following case is an example of the difficulties one may encounter both with the diagnosis and with the treatment of such a condition.

A highly neurasthenic woman 43 years of age was under observation in the medical wards of the hospital in *1926* for a mitral stenosis and aortic insufficiency associated with severe cephalalgia. At that time partial deafness and other symptoms suggesting a possible left cerebello-pontile angle tumour were noted.

On *May 26, 1927*, she returned (Surgical No. 28877) because of an increase in the neurological symptoms whose chronology follows. She had had a transient diplopia lasting 8 months in *1924;* a gradually increasing numbness in the left side of the face beginning in *1925* and associated with attacks of vertigo and staggering; more recently she had been troubled chiefly by neuralgic pains of the second and third divisions of the left trigeminal nerve.

It is evident from the records that there was much confusion about the diagnosis. There was no papilloedema and she had never had vomiting with her occasional headaches. She had frequent nose-bleeds. A definite exophthalmos was present in the left eye which showed an internal squint. There was numbness of the left face but the left deafness noted at the previous admission (*1926*) had largely disappeared. Fairly definite right-sided pyramidal symptoms were present. She was a highly nervous, difficult patient and at her own request was discharged without operative intervention. During *1928* the symptoms advanced and finally attacks of unconsciousness following severe headaches obliged her again to seek readmission.

She entered the hospital for the third time on *December 6, 1928*, when the most striking symptoms were the impairment of the left trigeminal nerve and the left external rectus palsy with neurokeratitis of the left eye. It was thought

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[71] Cruveilhier's 'Tumeurs Perlées." Surg., Gynec. & Obst., 1920, XXXI, 390–401.

[72] A consideration of the dermal versus the epidermal cholesteatomas having their attachment in the cerebral envelopes. Arch. Neurol. & Psychiat., 1922, VIII, 265–285.

[73] A large epidermal cholesteatoma of the parieto-temporal region deforming the left hemisphere without cerebral symptoms. Surg., Gynec., & Obst., 1922, XXXIV, 557–566.

that she probably had a meningioma of the temporal fossa involving the Gasserian envelopes. A left osteoplastic flap was accordingly made and the dura was separated from the bone down to the foramina of exit for the maxillary and mandibular nerves without disclosing a lesion. The dura was then opened and the trigeminus exposed from above. A most remarkable picture was thus brought to view. All that was left of the Gasserian ganglion was a thin film of tissue spreading out over a glistening tumour, evidently a cholesteatoma (Fig. 79) about 2 cm. in diameter. This tumour was thoroughly cleaned out; even the pearly membrane was thought to have been wholly removed, the lateral cavernous sinus having been fully exposed in this process. From this operation she made a perfect recovery; and in the vain hope that this small lesion of the middle fossa accounted for all her symptoms, she was discharged on *January 3, 1929*.

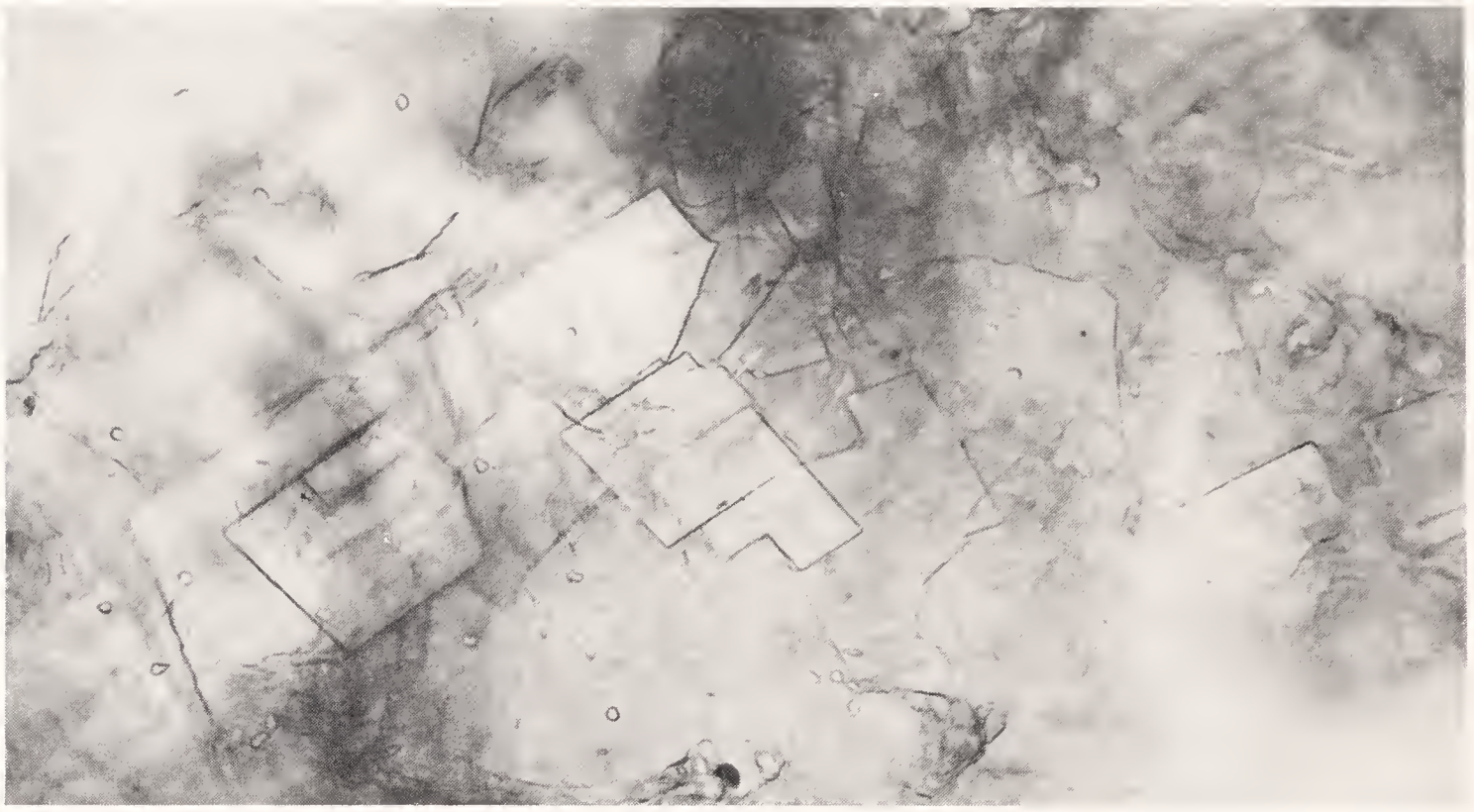

FIG. 79. Typical crystals of cholesteatoma shown on fresh smear (×300).

The only thing gained by this operation, as time proved, was the cessation of her trigeminal pain. Though she was seen frequently, it was not until some months had passed that, owing to a definite accession of cerebellar symptoms, the suspicion of a subtentorial expansion of the original cholesteatoma into the adjacent cerebello-pontile angle was aroused. Her gait had become increasingly ataxic, nystagmus was pronounced, and there was symptomatic involvement of all the cranial nerves on the left from the sixth to the twelfth, with marked dysarthria and dysphagia.

She consequently was admitted to hospital for the fourth time and on *November 8, 1929*, an exploration disclosed a large cholesteatoma of the recess over which the cranial nerves were expanded (Fig. 80). It was difficult to work at the tumour in between the nerves but its cheesy contents were finally in large part excavated. The attempt was then made completely to remove the pearly capsule, which was pursued well up through the tentorial incisura where a visible fragment lying against the left cerebral peduncle finally had to be left behind. The root of the trigeminal nerve was purposefully divided and all the other nerves had necessarily been more or less traumatized.

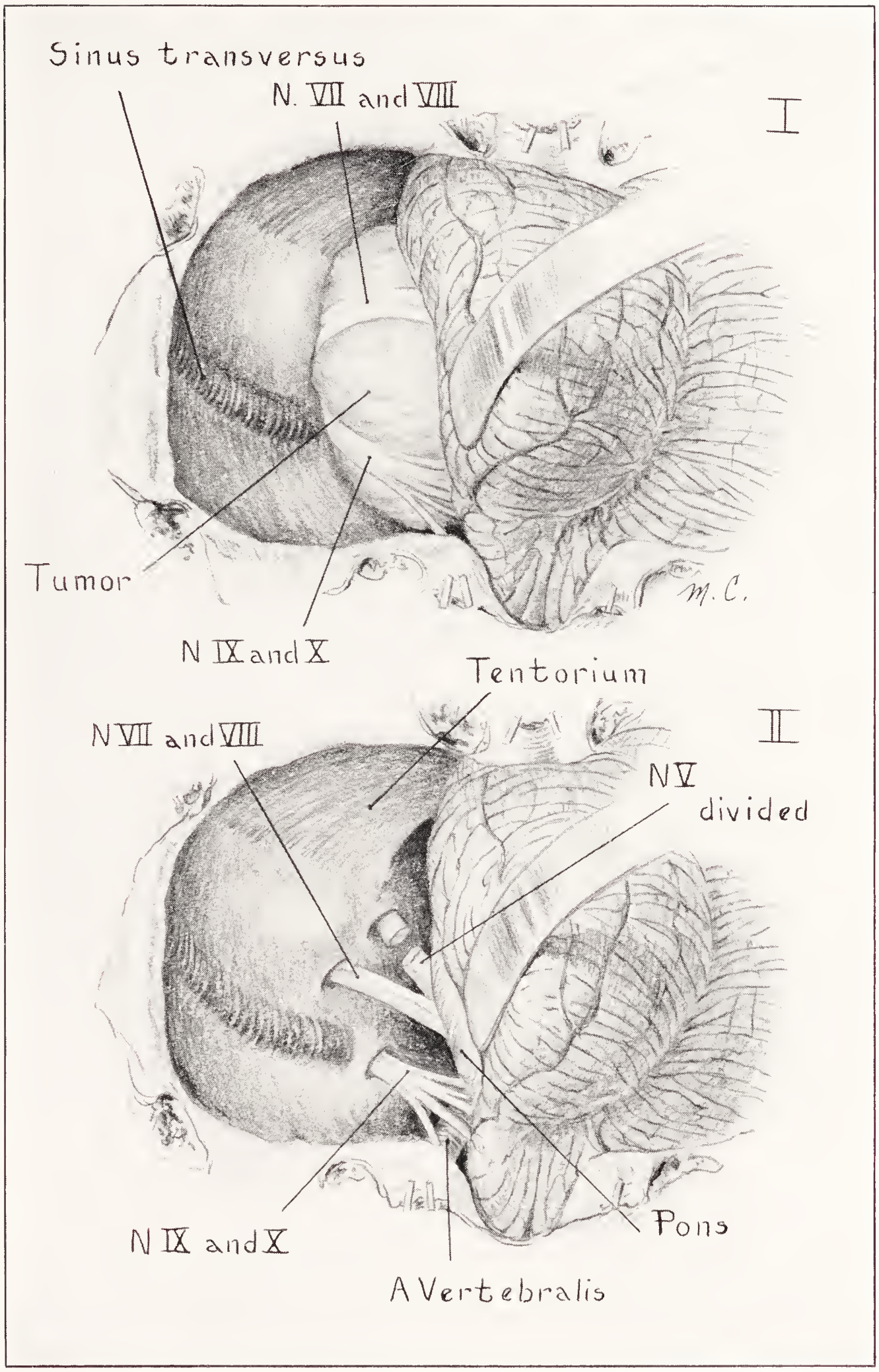

FIG. 80. Operative sketches showing large pearly cholesteatoma in left cerebello-pontile recess. Lesion previously operated upon by a left lateral craniotomy with removal of expansion of tumour from under Gasserian ganglion.

From this tedious four-hour operation under local anaesthesia the patient made a surprisingly good recovery and was discharged on *December 2, 1929*. Curiously enough, what has subsequently troubled her most is an intolerable tinnitus; so that it would probably have been better to have divided the auditory as well as the trigeminal nerve. She has grown dependent on drugs and at the present time (*July 1931*) gets very little out of life apart from the attention of a devoted husband.

Statistics.—For the 15 cholesteatomas and dermoids 22 operations have been performed with 3 fatalities giving a 20 per cent case-mortality and a 13.6 per cent operative mortality.

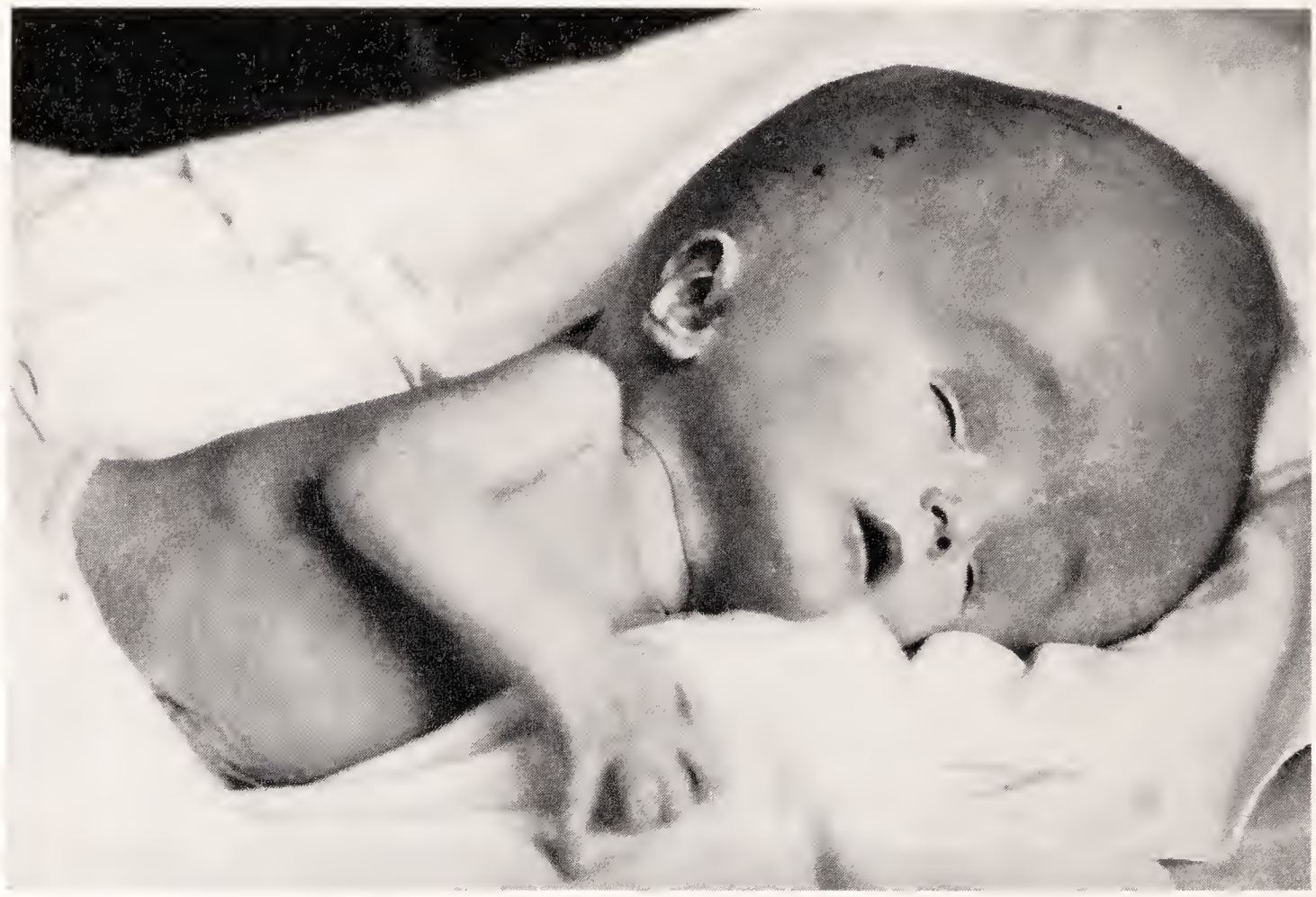

FIG. 81. Showing supposedly hydrocephalic infant who proved to have a huge intracranial teratoma (*cf.* Fig. 82).

TERATOMAS AND CHORDOMAS

These lesions are so rare as scarcely to have any surgical bearing and their interest is largely histopathological.

The four *teratomas* vary from a small tumour of the pineal body, to two obscure parahypophysial tumours—one of them of large size—and finally to a huge complicated multicystic lesion occupying a large part of the head of a supposedly hydrocephalic child. This latter case may justify the following brief note:

On *November 22, 1928,* an infant 2 months of age (Surgical No. 32715) was referred to us from the Infants Hospital because of a rapid increase in the size of the head which had supposedly been normal at birth. An exploratory puncture had disclosed xanthochromic fluid thought to have come from the ven-

tricle. The child had subsequently received daily punctures, either lumbar or ventricular, without checking in any way the rapid progress of the condition.

Examination showed an infant with an enormous symmetrically enlarged head, measuring 71 cm. in circumference (Fig. 81). Irregular calcified areas scattered in various places throughout the expanded cranial chamber were apparent on the cranial roentgenograms. There were areas of cranio-tabes in both parietal regions. Through one of them a needle was inserted and at the depth of 3 cm. a resistant gritty mass was encountered. A tap in another direction struck xanthochromic fluid resembling the fluid of a gliomatous cyst. This cyst

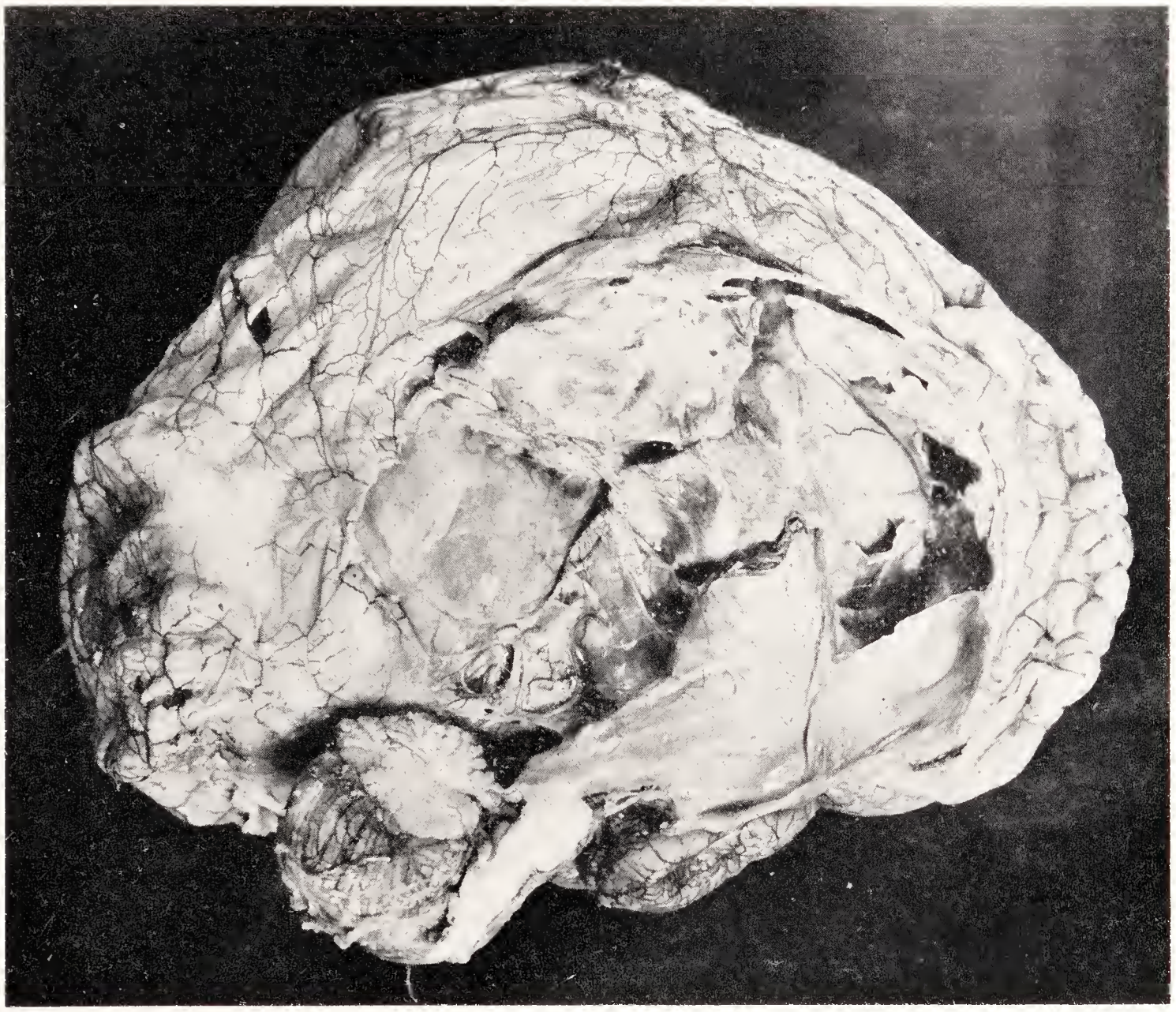

FIG. 82. Median section of brain of infant (*cf.* Fig. 81) to show (much reduced) the large central tumour enveloped by paper-thin cortex.

was apparently multilocular and about 150 cc. of fluid were withdrawn and replaced by air. The same procedure was repeated on the right side of the head.

Subsequent cystograms showed an irregular, lobulate central mass which apparently shifted in location and which contained multiple areas of calcification. The huge tumour evidently occupied the major central portion of the greatly enlarged head. The child gradually acquired decerebrate rigidities and finally died of inanition, no operation having seemed justifiable.

At autopsy the huge brain with enclosed tumour was removed so far as possible within the intact dura. A mid-sagittal section (Fig. 82) of the specimen was made after fixation. It passed through the centre of a huge calcareous

tumour which expanded more or less symmetrically into both lateral hemispheres. The cerebral cortex was in many places paper-thin and the tumour loosely occupied the hugely dilated ventricles. It evidently was not a craniopharyngioma for the third ventricle and chiasm, though flattened out to the thinnest possible strands of tissue, were otherwise uninvolved.

Sections taken from various portions of the growth contained bone, cartilage, striated muscle, fat and muco-epithelial lined cysts.

The two *chordomas* (Ribbert) so far identified in the tumour collection have been made the subject of a report from the clinic[74] in which will be found the bibliography of these interesting lesions which arise from a congenital abnormality of the *Clivus Blumenbachii*. Both of the tumours have also been cited in other connections: one in relation to the differential diagnosis of tumours producing the "chiasmal syndrome" (Case 13)[46]; the other, encountered as long ago as 1909, was reported in my pituitary monograph (1912, Case XVII) as an "interpeduncular teratoma" with dyspituitarism.

Statistics.—The figures for the combined group of 113 miscellaneous congenital tumours, of which 106 have been operated upon 160 times with 23 deaths, give a 21.7 per cent case-mortality and a 14.4 per cent operative mortality. Instead of being improved during the past three years, these figures have been augmented by four fatalities ascribable to over-radical attempts to deal with certain craniopharyngiomas by a transventricular exposure. For this recent period there have been 17 cases with 25 operations and the 4 deaths mentioned, giving a present-day 23.5 per cent case- and a 16 per cent operative mortality.

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[74] Bailey, P., and Bagdasar, D. Intracranial chordoblastoma. Am. J. Path. 1929, v, 439–449.

VI. Metastatic and Invasive Tumours

Under this heading are assembled a variety of malignant tumours which do not arise primarily in the brain though the fact in many instances may not be suspected until the lesions have been examined, after their surgical removal.

THE METASTATIC LESIONS

These, 65 in number, comprise 48 carcinomas, 12 sarcomas, and 5 hypernephromas. Their relative scarcity in the series of brain tumours as a whole, viz., 3.2 per cent, by no means represents their true clinical incidence, for we refrain when possible from accepting patients with obvious intracranial metastases since so little can be done for them by surgical procedures. Most of these metastatic tumours consequently have been stumbled upon unexpectedly and the series contains many bizarre experiences such, for example, as: (1) a single large melanotic sarcoma which had its origin in an ovarian dermoid; (2) a supposedly innocent post-traumatic subdural clot in the centre of which metastatic nodules of a carcinoma of the prostate were found; (3) the removal, from the cerebellum of a tuberculous woman, of a supposed tuberculoma which proved histologically to be a metastatic carcinoma.[75]

In a report dealing with the unhappy experiences of the Brigham clinic with the 26 cases to March 1, 1926, Dr. Grant[76] stated that "the average length of life from time of admission to death in both verified and unverified cases, whether operated upon or not, and whether the lesion was treated by radical extirpation or palliative decompression, was less than four months." This statement, however true in fact, fails to indicate that operations nevertheless may not infrequently afford a vast degree of symptomatic relief for which patients and their relatives are most grateful. Hence when the unfortunate victims of these disorders once come to be admitted to the hospital wards, it is difficult to refuse their appeals to give them at least the chance of temporary palliation of symptoms which a decompression may afford.

(*a*) *Carcinoma*.—Metastases of mammary origin are usually betrayed either by the presence of a suspicious mammary nodule or by evidence of a recent amputation of the breast, whether for known or presumptive malignancy. The following is a fairly typical experience:

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[75] Meagher, R., and Eisenhardt, L. Intracranial carcinomatous metastases, with note on relation of carcinoma and tubercle. Ann. Surg., 1931, xciii, 132–140.

[76] Grant, F. C. Concerning intracranial malignant metastases: their frequency and the value of surgery in their treatment. Ann. Surg., 1926, lxxxiv, 635–646.

The patient, a spinster 46 years of age (Surgical No. 38123), was admitted *January 31, 1931*, with the history of headache and aphasia of rather abrupt onset and of five weeks' duration, obliging her to give up her occupation as an insurance clerk. Examination revealed the scar of a radical amputation of the right breast and it was learned that this had been performed 18 months before admission, the pathological diagnosis having been adeno-carcinoma.

She was found to have bilateral choked discs, a defect of speech chiefly characterized by a pronounced anomia, and a partial right homonymous hemianopsia. The site of the old breast amputation was free from local recurrence and there was no evidence of metastases elsewhere.

The remote chance was taken of finding an isolated lesion and of temporarily benefiting her by operation. Accordingly, on *February 7*, a left osteoplastic exploration under local anaesthesia was made. A partly cystic tumour about the size of a hen's egg situated in the temporal lobe was exposed and, so far as could be told, completely enucleated (Fig. 83). The supravital preparation (Fig. 84) showed it to be unmistakably carcinomatous.

From this operation the patient made a prompt recovery and was discharged from the hospital on *February 21*, apparently symptom-free, with complete disappearance of her field defects and her aphasia. At the present writing, five months later, she remains in excellent condition and has no discomforts though she is evidently beginning to lose ground.

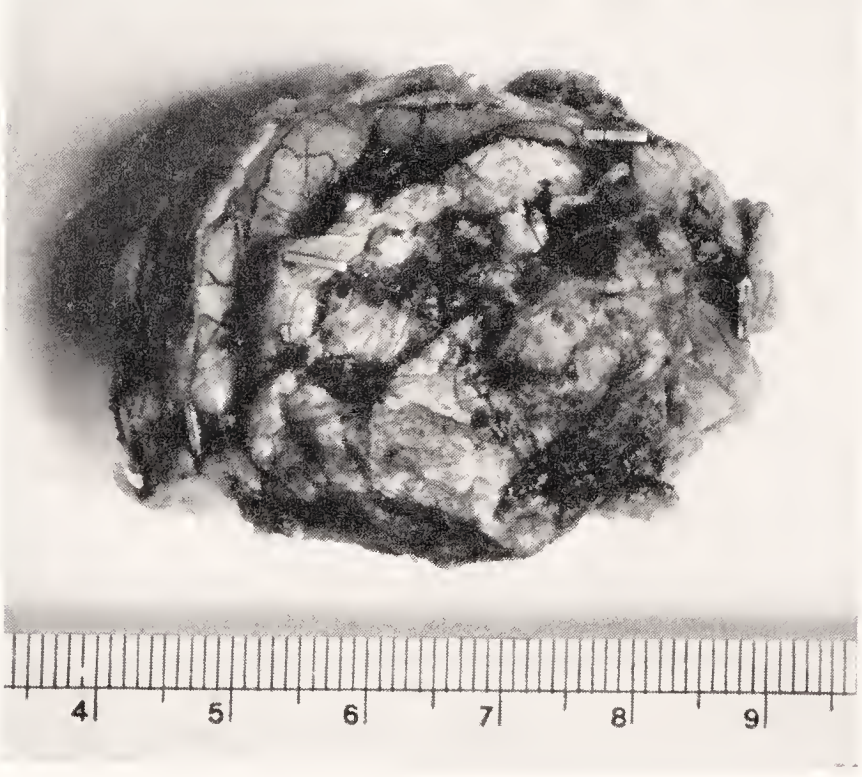

FIG. 83. The metastatic temporal tumour partly covered by cortex, after its operative removal.

In this instance there could be no question regarding the diagnosis; but when the precise nature of the original tumour is obscure or when a long interval has elapsed between the original operation and the onset of cerebral symptoms, one may feel still more justified in making an exploratory operation. Nor should it be forgotten that occasionally the symptoms of a brain tumour following a recent amputation of the breast for carcinoma may actually be due to a primary and not to a metastatic tumour. An example of this has been given by Meagher and Eisenhardt in their paper cited above. They furthermore have pointed out that carcinoma metastases from the breast have been less common than from the lung, the former at the time of their calculation representing 25 per cent and the latter 35 per cent of all metastatic cerebral lesions. But this probably is an indication merely that patients with metastatic pulmonary lesions are, of the two, the more likely to be admitted to the clinic for oper-

ation since a bronchogenic carcinoma long remains a clinically silent lesion.

This feature of primary lung cancers—their insidious course—has been stressed by Fried and Buckley[77] in a paper in which 15 examples from the Brigham collection with metastases to the brain were reported in detail. What is more, the cerebral metastases from these slowly growing cancers at the hilus of the lung may occasionally appear to be solitary lesions and to have in themselves a fairly good prognosis after operative removal; some of them, indeed, were extirpated under the mistaken impression that they were meningiomas and not until their true nature was

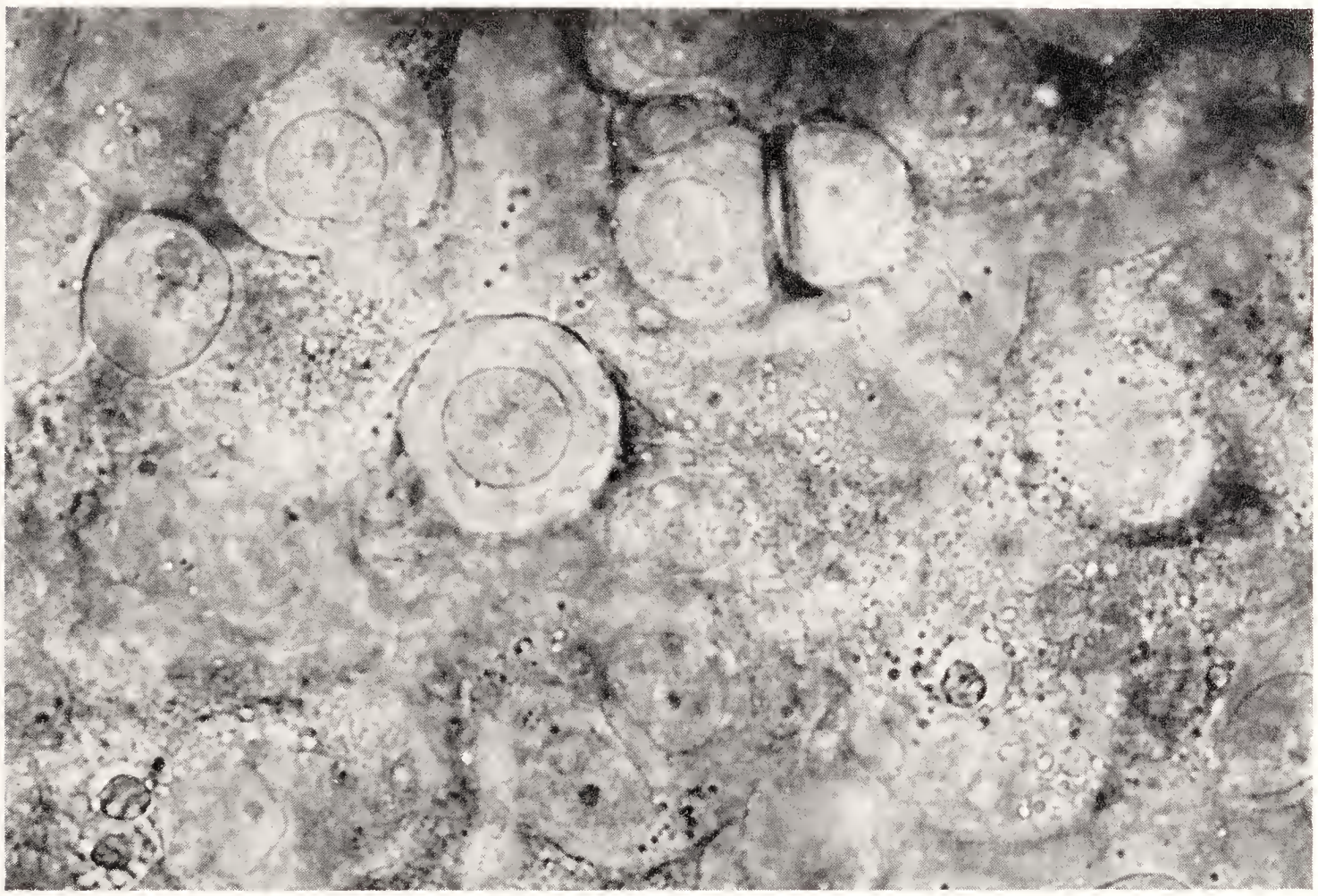

FIG. 84. Supravital preparation (×850) of metastatic carcinoma showing cancer cells in débris of degenerated tissue.

histologically identified were roentgenograms taken of the chest and the primary tumour of the lung thus disclosed. The case with the longest survival period in the series is as follows:

On *Jan. 16, 1923,* an easily enucleable 51-gram tumour was successfully removed (Fig. 85) from the left supramarginal gyrus of a Jewish rabbi (Surgical No. 18053) who had previously shown a global aphasia. A complete recovery followed, the gradual disappearance of the aphasia and apraxia having been studied and reported upon by Bailey.[78] The tumour was diagnosed as a hyper-

[77] Fried, B. M., and Buckley, R. C.: Primary carcinoma of the lungs. IV. Intracranial metastases. Arch. Path., 1930, IX, 483–527.

[78] Bailey, P. A contribution to the study of aphasia and apraxia. Arch. Neurol. & Psychiat. 1924, XI, 501–529.

nephroma or possible chordoma and long remained in our indeterminate group of miscellaneous tumours.

Owing to a recurrence of symptoms seven months later a second operation was performed *August 20, 1923*, when a precisely similar 42-gram tumour (Fig. 86) was removed from the same situation as before. Again there was a prompt and complete symptomatic recovery. He remained symptom-free and led a normal active life for five years when on *September 4, 1928*, he reëntered the hospital because of a troublesome inguinal hernia which was successfully repaired. In the absence of any further cerebral symptoms, he nevertheless at this time was again thoroughly gone over to disclose if possible the primary source of his former metastatic lesion. Stereoroentgenograms of the lungs showed the shadow of a growth involving the right upper lobe.

FIG. 85. The nodular tumour (an unsuspected metastatic carcinoma of the lung) removed at the primary operation.

Two months later he was readmitted to the medical service because of rapidly failing health. At this time an increase in the pulmonary lesion was evident to the X-ray and apparent metastases to the bones were disclosed. He was transferred to another hospital where he died, unfortunately without a post-mortem examination, on *November 22, 1928*, seven years from the onset of his cerebral symptoms.

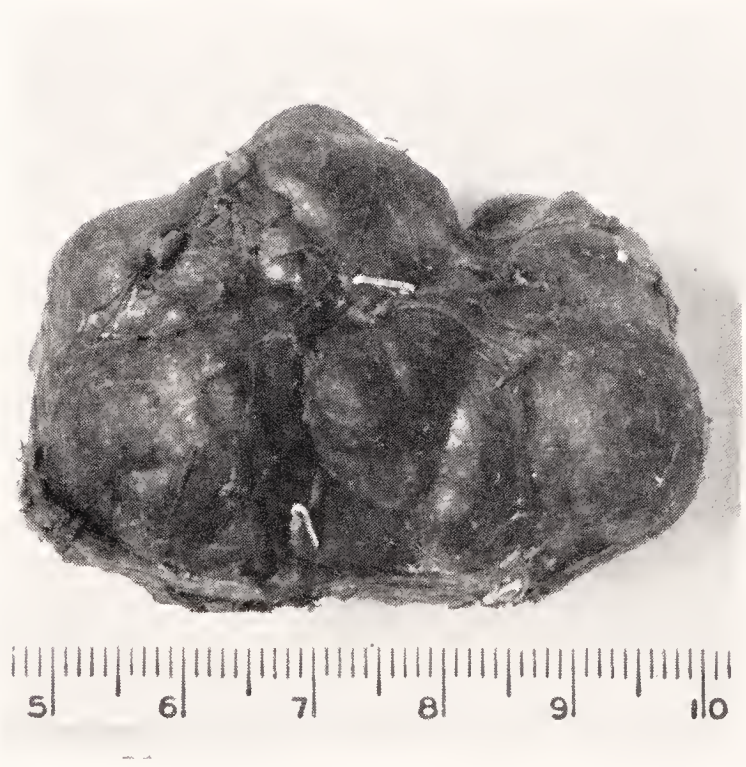

FIG. 86. The recurrent tumour removed at a secondary operation 7 months later (*cf.* Fig. 85) with freedom from symptoms for five years.

Ordinarily metastases to the brain are multiple, so that if this patient died without secondary cerebral lesions it would be most exceptional. Nevertheless one may occasionally encounter what appear to be solitary tumours sometimes of comparatively large size (Fig. 87); and the fact that other patients than the one whose case has been cited above have had unexpectedly long postoperative survival periods (3 years in one case; 2 in another) after the removal of a metastatic carcinoma

brings a certain gleam of hope to what surgically is an otherwise most gloomy subject.

The *mortality percentages* for these cases are among the highest of any group in the series, due largely to the fact that the hospital sojourn is likely to be prolonged until the end. Of the 48 verified examples 39 have been operated upon 50 times with 15 fatalities, giving a 38.5 per cent case-mortality and a 30 per cent operative mortality.

(*b*) *Sarcoma*.—Examples of metastatic sarcoma, while less numerous than the above, from a prognostic standpoint are even more serious. In our experience they have for the most part been melanotic lesions usually of cutaneous origin. The last case in the series, which may serve as a type, is briefly as follows:

Twelve years prior to his entry the patient, an attorney aged 49 (Surgical No. 38478), had had a "nerve tumour" removed from his right leg. Six months

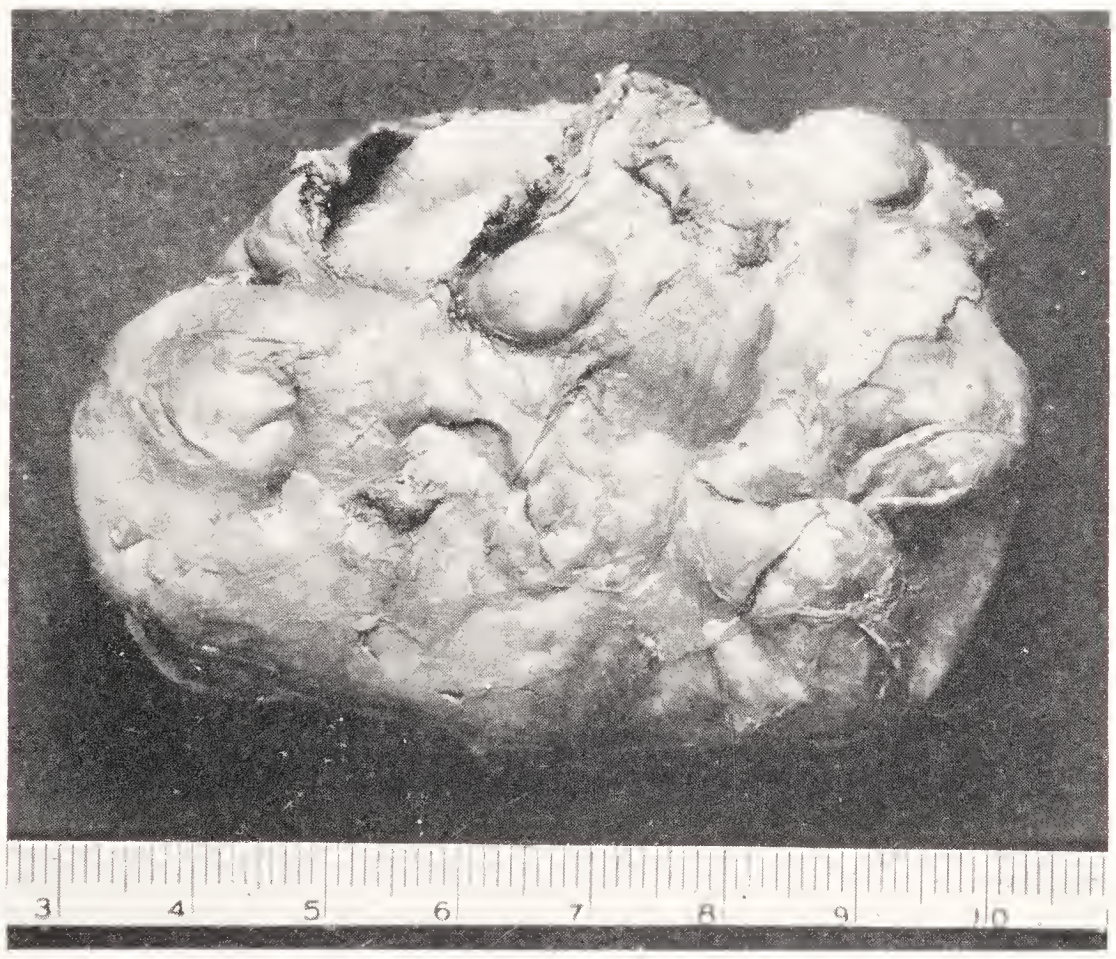

FIG. 87. A large, partly cystic carcinoma metastatic from lung (Surgical No. 30684) with recovery for three years. Death from pulmonary embolus on 5th day after secondary operation for local recurrence.

before admission, another tumour said to have been a "metastatic carcinoma" was removed from his right axilla. In addition, he had had two operations 25 and 12 years previously for a thyroglossal duct cyst.

He entered the hospital *March 23, 1931*, with headache, nausea and vomiting of recent onset. There was a high grade of choked disc but no definitely localising symptoms. The probable metastatic origin of his trouble was recognized but a ventriculogram was made which showed slightly dilated ventricles with a definite forward kinking of the aqueduct of Sylvius as though from a local tumour.

A temporizing subtemporal decompression was performed, but this failed to alleviate the symptoms in the slightest degree and he was finally discharged on *April 17*, and died at his home a month later. A postmortem examination was performed and the brain was forwarded to us for study. It showed two metastases: one a small growth in the left frontal region, and another (Fig. 88) a centrally placed lesion high in the cerebellar vermis. The original diagnosis, "tumour unverified: probable metastatic carcinoma," was thereby changed to "tumour verified: metastatic sarcoma."

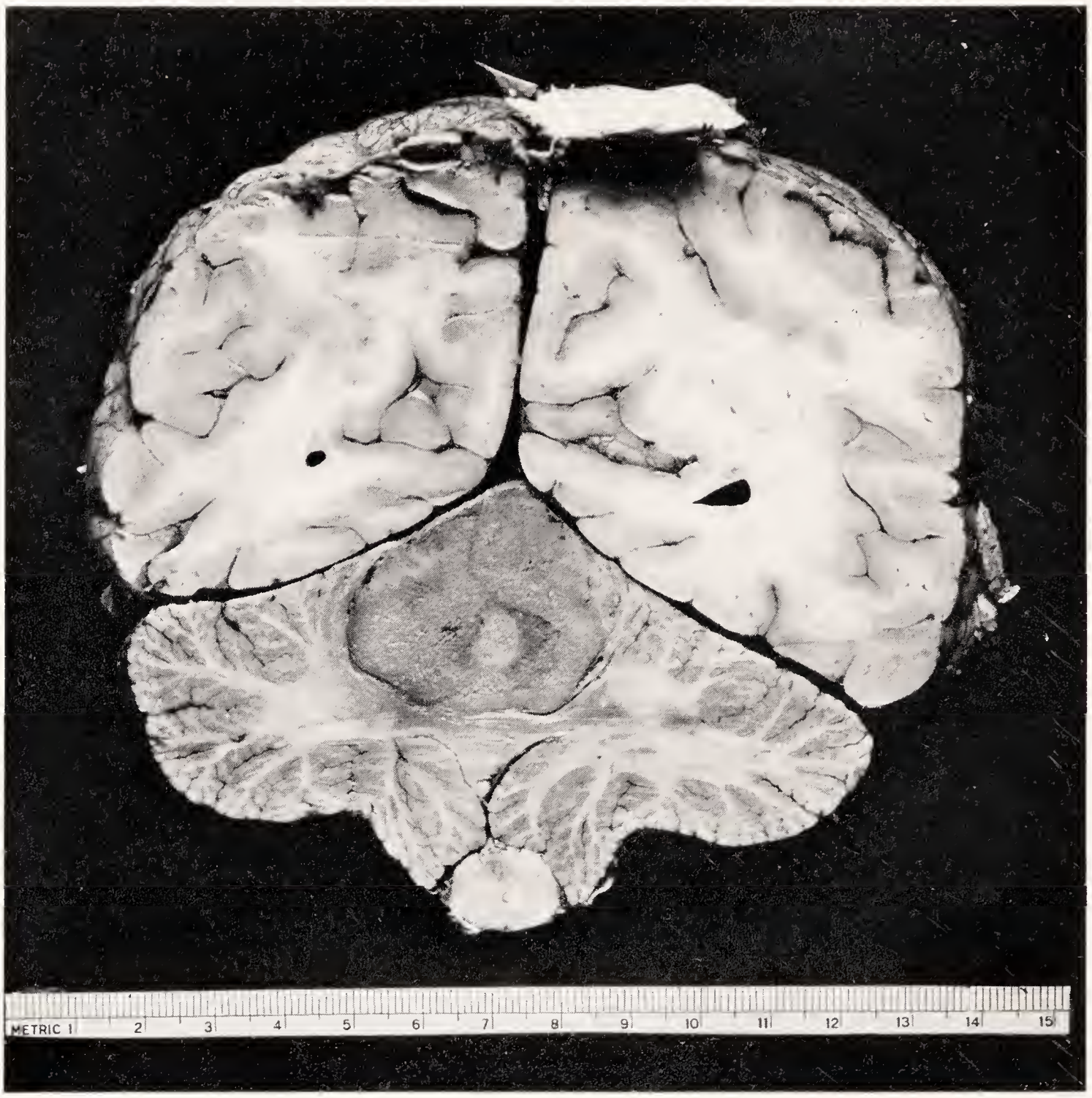

FIG. 88. Metastatic sarcoma of anterior cerebellar vermis in case cited.

Nine of the 12 metastatic sarcomas recorded have been operated upon 10 times with two fatalities, giving a 22.2 per cent case- and a 20 per cent operative mortality.

(c) *Hypernephroma.*—There have been 5 examples of metastatic hypernephroma to the brain, 2 of them having metastases to the skull as well. It is my impression that metastases of this nature are more favour-

able than those from a primary sarcoma or carcinoma. Naturally enough, a preoperative pathological diagnosis is not likely to be made, and in all instances the true nature of the lesion has not been suspected until the histological study of the tissues has been made. The following is an example:

The patient, John G., a carpenter 58 years of age, was admitted *August 28, 1929,* (Surgical No. 34711) with a history of headaches for six months, marked loss in weight, and recent intermittent periods of coma. Until a choked disc was detected, he had been thought to have general paresis though his Wassermann reaction was negative.

Owing to his somnolent condition a neurological examination was unsatisfactory and on *September 4,* in the process of making a ventriculogram, a cyst containing xanthochromic fluid was unexpectedly tapped in the right hemisphere. The cyst was filled with air permitting its location in the posterior parietal region to be roentgenologically demonstrated. At operation on *September 12,* Dr. Horrax by electro-surgical methods exposed and removed a partly cystic, definitely enucleable tumour.

The patient's coma was not relieved by this operation and on the following day the flap was reëlevated on the assumption there must be a clot; but none was found. He died later in the day apparently from hyperthermia associated with evident respiratory failure.

A postmortem examination was held and this disclosed a hypernephroma of the left kidney, "gastromalacia" with perforations of stomach and eosophagus; also broncho-pneumonia. The cerebral metastasis had evidently been removed intact and the brain showed no evidence of oedema or injury due to the enucleation. There were no other cerebral metastases, nor were any metastases found elsewhere in the body. The primary lesion was a large necrotic tumour within the substance of the left kidney measuring 16 by 9 by 9 cm. Tumour tissue was found in the lumen of the renal vein.

Statistics.—Three of the 5 verified metastatic hypernephromas were operated upon 4 times with this single fatality, making a 33.3 per cent case-and a 25 per cent operative mortality.

MALIGNANT INVASIVE LESIONS

These, 20 in number, include a variety of malignant tumours of the skull, either primary or metastatic, which have secondarily come to involve the brain by direct extension. They are divided into 8 sarcomas, 8 carcinomas, and 4 myelomas. An example follows:

The patient, a nurse 66 years of age (Surgical No. 21057) was admitted to hospital *November 20, 1923.* She had unmistakable osteitis deformans of Paget, chiefly involving the skull in which a huge lateral swelling betokened a sarcomatous degeneration of the lesion.[79] Unfortunately some one a short time before had incised the swelling, which was soft and warm to the touch, under the impression that it was a huge abscess. At the site of this incision there was a small fungating protrusion (Fig. 89). She was showing evident pressure symptoms with a beginning choked disc.

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[79] Bird, C. E.: Sarcoma complicating Paget's disease of the bone. Report of nine cases, five with pathologic verification. Arch. Surg., 1927, XIV, 1187–1208 (Case 1).

The tumour had been growing rapidly but it was hoped that the unfortunate woman might be spared the horror of a large suppurating fungus, could enough of the tumour be removed to make it possible to replace the scalp after closure of the galea from within at the site of the existing protrusion.

Accordingly on *December 5*, a large flap of scalp was turned down exposing the entire growth whose chief extracranial mass was removed. The tumour was soft, excessively vascular, and spiculated throughout with fragments of bone. Had it not been that an abundance of raw muscle, secured from a breast ampu-

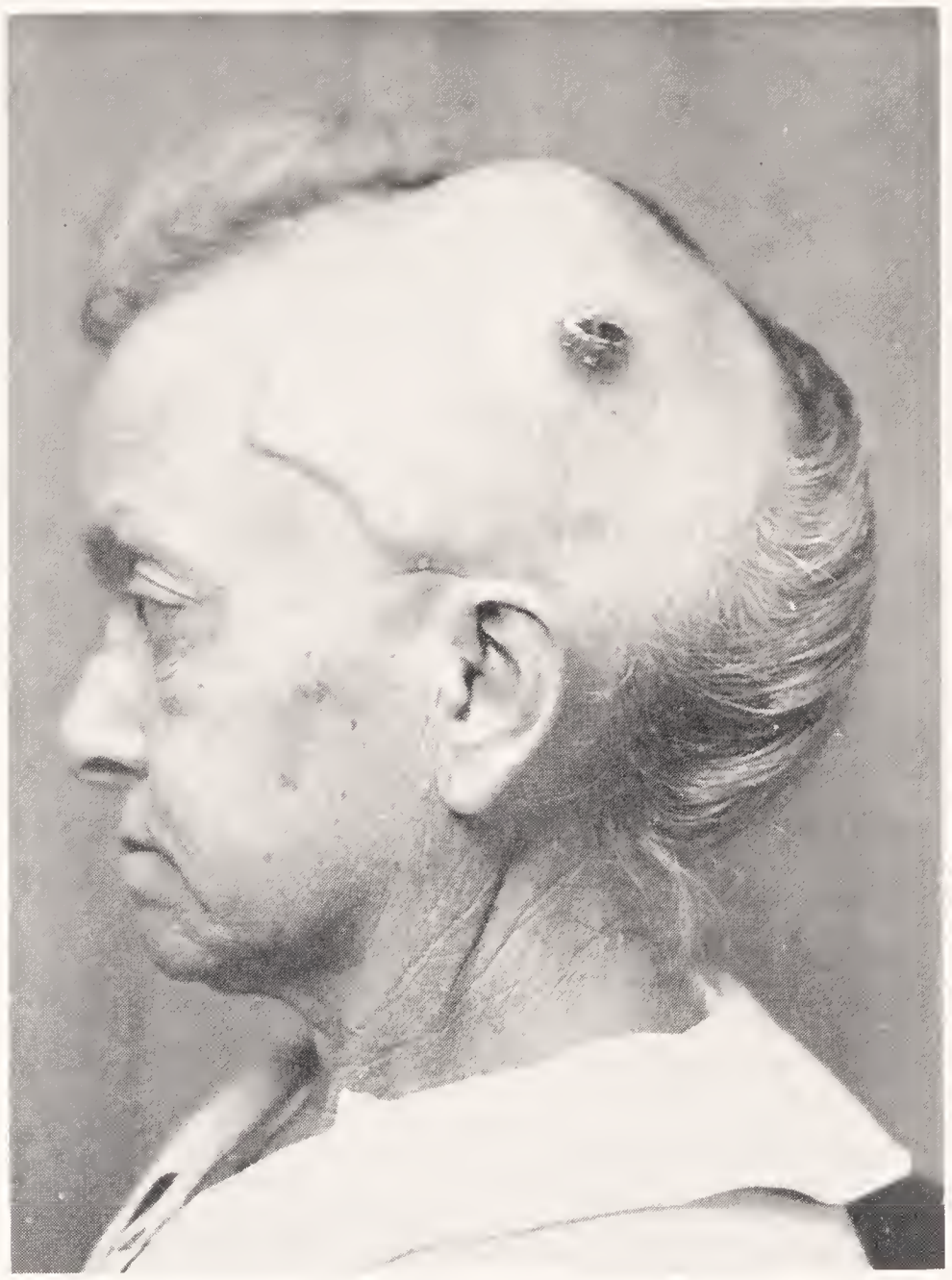

FIG. 89. Patient with Paget's disease, with fungus developing at site of exploratory incision of huge cranial sarcoma which was mistaken for an abscess.

tation that had been purposefully scheduled for the same morning, was at hand, it is probable that bleeding could not have been controlled. After the tumour had been roughly scooped out to below the level of the skull the entire pectoralis major was implanted and held in position until bleeding ceased. There was marked pulsation in the base of the great cavity showing that intracranial tension produced by the tumour's pressure had been relieved.

Before replacing the scalp the small fungating protrusion was excised and the galea sewed securely together from within.

The patient made an unexpectedly good recovery from this desperate pro-

cedure and three days later, on *December 8*, the flap was again reflected, the muscle was dislodged, and some further great masses of the thick tumour-invaded bone were rongeured away, it being necessary to re-implant some of the old muscle to make sure of haemostasis. From this operation likewise she made an excellent recovery and was discharged on *January 2*, wholly relieved of her preëxisting headaches and with a clean scalp.

The tumour proved to be a typical, rapidly growing osteosarcoma with giant cells and abundant mitoses. As was to be expected there was a rapid recurrence of the growth and her respite was brief. Knowing of our interest in the nature of her trouble, and expressing the desire that we should make a thorough post-mortem study of her disorder, this unfortunate woman reëntered the hospital where she ultimately died (Fig. 90).

FIG. 90. Skull of the patient with osteitis deformans showing the defect produced by a huge osteosarcoma.

In this collection of 20 invasive tumours, 12 have been operated upon 16 times with no postoperative fatalities in hospital.

Statistics.—The figures for the entire group of 85 metastatic and invasive lesions combined show for the 63 patients operated upon 80 times with 18 fatalities, a 28.6 per cent case-mortality and a 22.5 per cent operative mortality.

The fact that during the last three-year period there have been 4 fatalities in 10 cases with 11 operations gives for this recent interval a bad record, namely a 40 per cent case- and a 36.4 per cent operative mortality, which is partly ascribable to our having on three occasions been led to undertake exploratory operations for tumours that were not known to be metastatic.

VII. Granulomata

Whether these lesions should properly be included in a tabulation of brain tumours any more than should aneurysms or abscesses or, in countries where they abound, parasitic cysts, may be debatable. None of them is truly "neoplastic" in the accepted meaning of the term though they offer problems, diagnostic and surgical, which not only resemble those presented by actual tumours but in some regards are even more difficult to solve. Solely out of respect to tradition the bacillary granulomas of the brain continue to be recorded as tumours and if this is illogical time will correct the error for they are fast eliminating themselves.

Tuberculomas.—Whereas in tabulations compiled forty years ago these lesions represented from 30 to 40 per cent of all intracranial tumours, in proportion to the decline in the incidence of tuberculosis they now have fortunately become scarce. There were eight examples in my Johns Hopkins series of 194 verified tumours, making 4.1 per cent. At the time of Dr. Van Wagenen's detailed description[80] of the fourteen tuberculomas recorded in the Brigham series up to October 15, 1925, they then represented 1.4 per cent of all verified tumours, and this remains essentially a stationary figure. In countries where bovine tuberculosis is more prevalent than in America, the percentage may doubtless be higher, but such information as is available regarding this point is based on post-mortem rather than surgical records.

Tuberculomas, for some unknown reason, occur, in our series, in the hind brain three times more often than in the forebrain—at least those in the posterior fossa in our experience seem most likely to cause symptoms leading to surgical exploration. When a tuberculoma is surgically removed from the cerebellum, no matter with what care, a tuberculous meningitis is likely to ensue within three months. Owing to this disclosure it has been our custom when these lesions are surgically disclosed merely to leave the operation as a decompression and to put the child—for the patients are usually children—in surroundings most favourable for heliotherapy. Two children, one of whom has already been referred to in print,[81] have thus made apparently complete recoveries, the lesion as shown by successive roentgenograms having undergone progressive calcification during a five-year interval in one instance and a six-year interval in the other.

Such cases as these, however, fall in the list of unverified tumours, for without histological confirmation one can never be absolutely sure of the diagnosis. Of this I may give two illustrations. Two years ago a lesion taken to be a tuberculoma was exposed in a child's cerebellum and the

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[80] Van Wagenen, W. P. Tuberculoma of the brain: its incidence among intracranial tumors and its surgical aspects. Arch. Neurol. & Psychiat., 1927, xvii, 57–91.

[81] The intracranial tumors of preadolescence. Am. J. Dis. Child., 1927, xxxiii, 551–584 (Case 8).

operation was abandoned as a decompression; the child was placed in the country under favourable surroundings, and though the lesion became increasingly calcified, as shown by a series of X-ray films, the symptomatic condition did not improve. Consequently a second operation was performed and the growth was unexpectedly found to be a calcifying ependy-

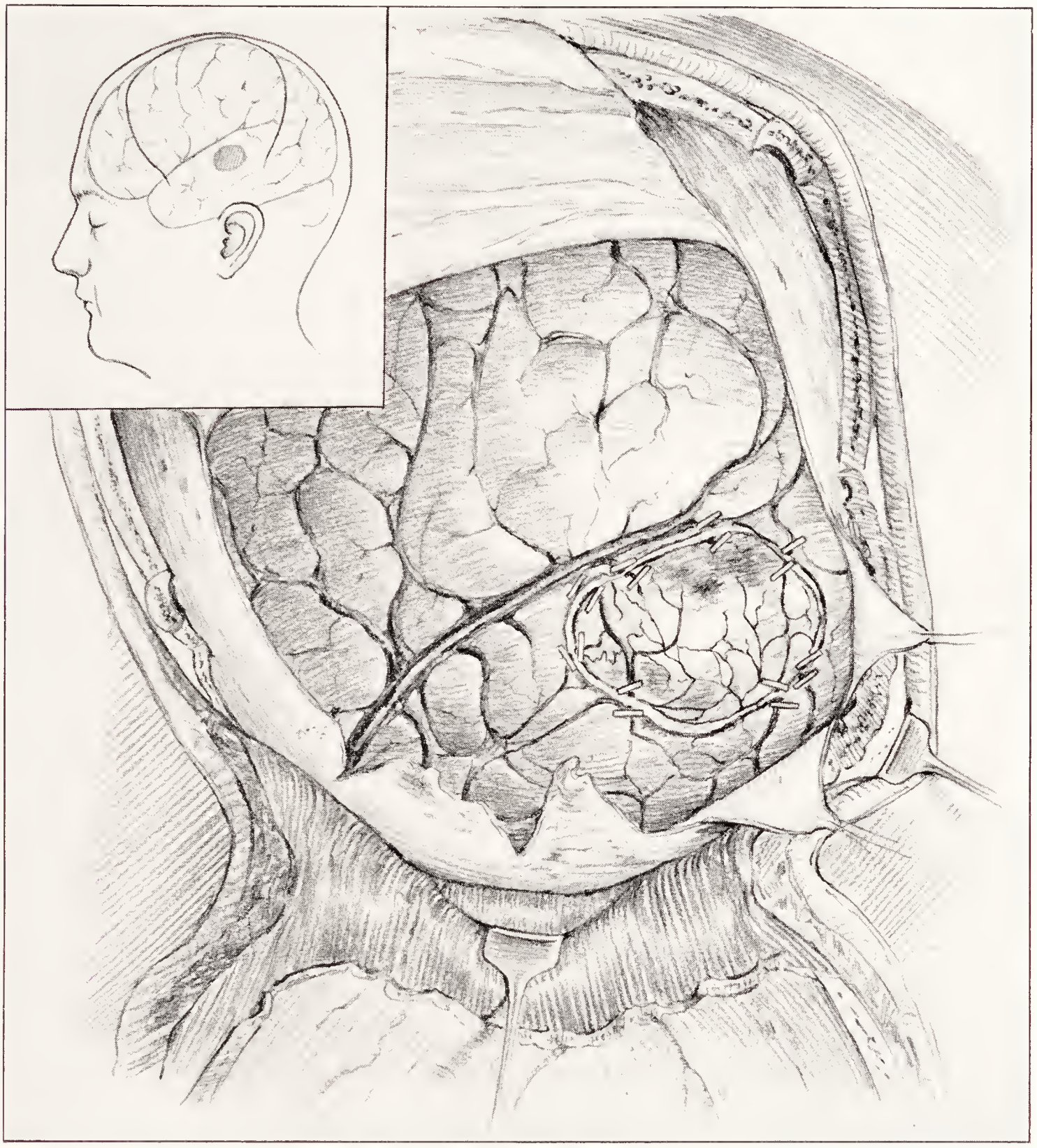

FIG. 91. Sketch of operative field to indicate appearance and site of tuberculoma mistaken for firm glioma and extirpated with 5-year recovery.

moma. Believing that electro-surgical methods, by sealing the meninges, might lessen the customary risks of meningitis after removal of a cerebellar tuberculoma, the tumour in another more recent case was carefully enucleated; when histologically examined, it proved to be not a tuberculoma after all but a xanthoma!—the only verified example of a tumour of this rare type in the series.

To be sure, surgical errors of diagnosis may be made in the opposite direction: namely, tuberculomas mistaken for tumours of other kinds. Since they are apt to be attached to the meninges they may closely resemble meningiomas, particularly when they have become densely cicatrized in process of healing, and two of the tumours in the series were removed under this belief. In the following case the growth was mistaken for a fibrillary astrocytoma:

A stenographer, Rose F., 29 years of age (Surgical No. 27384), was admitted *October 9, 1926*, with a four months' history of headaches, vomiting, failing vision, epileptiform attacks, and fatigability. She was a well nourished young woman with bilateral choked discs of 4 diopters, more advanced in the left eye, weakness of the right lower face and right hand, and slow cerebration. Most of the attacks were Jacksonian in character beginning in the right tongue and face and associated with aphasia. A definite "pineal shift" to the right was apparent on the cranial roentgenograms. There was slight continuous fever averaging a degree above normal without leucocytosis.

The signs pointed to a left temporal tumour and at operation on *October 13* a growth about 3 by 4 cm. in diameter which lay exposed on the surface (*cf.* Fig. 91) was excised by block extirpation (Fig. 92) under the assumption it was a firm glioma. Not until it was sectioned and studied was it found to be a fairly well organized tuberculoma.

Following this operation there was a marked temporary speech defect and an increased weakness of the right face, but these were soon recovered from, the papilloedema quickly subsided, and the patient was discharged *November 17, 1926*, in excellent condition. The epileptiform seizures continued for the next six months and then ceased. She has resumed her occupation as a typist and now, nearly five years since the operation, continues in perfect health. Repeated examinations have failed to reveal the primary source of the tuberculoma.

The only encouraging thing, generally speaking, about tuberculomas of the brain as encountered in a neurosurgical clinic is that they are more often single than multiple which may possibly be due to an accidental selective influence. This has been true in 13 of the 21 cases that have ultimately come to autopsy and should one be permitted to add to these the 10 unverified but surgically exposed tumours which were often large and presumably single, the proportion would be considerably augmented. The location of the verified single lesions has been the cerebellum in 11, in the pons in 5, and in the cerebrum in 8 instances. The pontile tumours are surgically hopeless and experience has shown that they are not in the least benefited by decompressive measures.

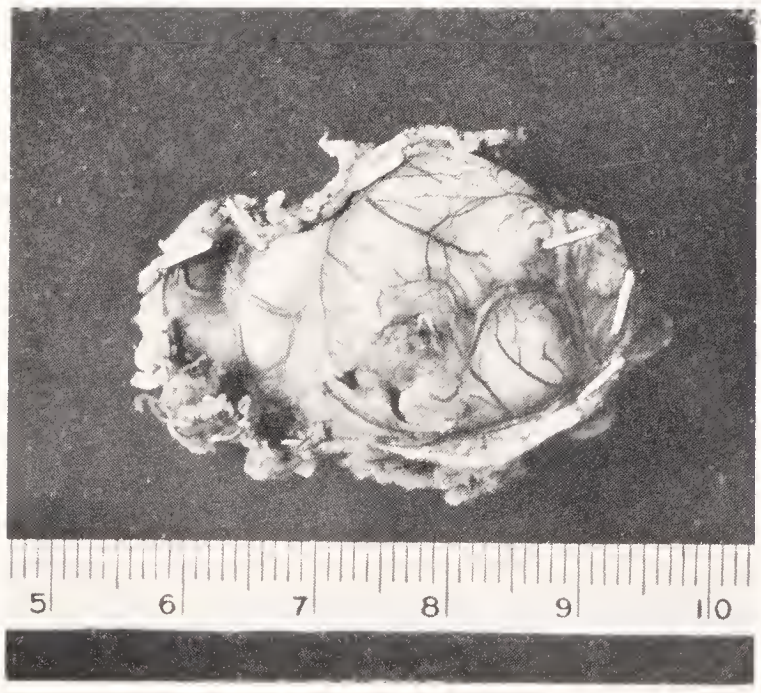

FIG. 92. Cortical surface of firm tumour (tuberculoma) after excision.

Owing to the small number of cases and to the differences in the behaviour and site of the tumours, surgical statistics regarding them do not amount to much. In general terms it may be said that single tuberculomas in the cerebrum have a better prognosis than those in the cerebellum. As already stated, the extirpation of a cerebellar tuberculoma has almost inevitably been followed after a variable interval by a fatal tuberculous meningitis. This in several instances has not taken place until two or three months have elapsed, but if it occurred while the patient was still in hospital it has obliged us to register the case as a postoperative fatality in order to adhere to our standard in this respect. A few surgically exposed but untouched cerebellar tumours have been accepted as "verified" provided the subsequently developing meningitis has been demonstrated to be tuberculous by lumbar puncture and guinea-pig inoculation even without autopsy; otherwise the tumours are listed as "unverified."

There have been 18 cerebellar explorations in the series, 5 of them with negative tumour exposure and 3 subsequent deaths in hospital, 7 with tumour exposed and extirpated with 4 deaths in hospital, and 6 with tumour exposed but not removed with a single postoperative fatality after 56 days. One of the latter six survived for a year before the postmortem histological verification of the tumour's precise nature made the diagnosis certain.

The percentage of fatalities has been even higher after cerebral than after cerebellar operations owing to the fact that these operations have been more likely to be performed in the presence of multiple lesions. Of the 11 patients, 10 were operated upon: the tumour was exposed but not removed in 3 instances with 2 fatalities; it was extirpated in 2 instances without fatality; and there were 5 negative explorations, all of them with death and autopsy in hospital. Only 3 of the cerebral cases therefore lived to be discharged, and only one of them [the case detailed above] may be said to have made a complete final recovery. The other two subsequently died at their homes, one of them three months later of generalized tuberculosis and the other, after an apparently successful removal of a large tuberculoma of the parietal lobe, died fifteen months after discharge from peritoneal tuberculosis.

Statistics.—Thirty of the 33 patients with verified tuberculomas were operated upon 35 times with 15 fatalities, giving a 50 per cent case- and a 42.9 per cent operative mortality. The lesson of experience has enabled us to avoid fatalities during the past three-year period during which there have been 5 operations on 4 cases without a fatality.

The Syphilomas.—These may be dismissed with brief reference. A critical study upon eight of the most interesting cases in the series observed up to 1927 has been made by Dr. Bagdasar.[82] Before Schaudinn's discovery in 1905 and Wassermann's application of it a year later, every

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[82] Bagdasar, D. Le traitement chirurgical des gommes cérébrales. Rev. neurol., 1929, II, 1–30.

intracranial tumour was regarded as a presumptive gumma until the patient had been subjected to the "diagnostic test" of a long antiluetic régime.

Whether a gumma of the brain has always been rare or whether it has become so since the introduction of modern methods of diagnosing and treating syphilis is uncertain; but it is interesting that 5 of the 12 examples occur in the Baltimore series of 194 cases observed up to 1911 and only 7 in the subsequent Boston series which contains ten times as many tumours. It is of course possible that the presence of a positive Wassermann reaction may encourage physicians to persist in medical treatment even in the presence of choked disc and definitely localising signs of tumour.

As a matter of experience, a cerebral gumma (and curiously enough these lesions differ from the tuberculomas in favouring the cerebrum) is notoriously resistant to antisyphilitic treatment, and as Horsley long ago emphasized, surgical measures are indicated in the majority of cases if for no other reason than the preservation of vision. The nature of the growth in most of the early cases was wholly unsuspected and the pathological diagnosis came as a surprise. This has also been true of some few of the later cases, in one or two of which both blood and cerebrospinal fluid had shown a negative Wassermann reaction.

Statistics.—Of the 12 cases in the series, 10 were operated upon 14 times in all with no fatalities. No cases have been encountered in the last three-year period.

VIII. Blood–Vessel Tumours

Under this caption are included both the angiomatous malformations and the true angioblastomas. In collaboration with Percival Bailey a detailed study of 29 of these lesions (16 angiomas and 13 angioblastomas) observed up to March 1, 1928, has already been published.[83] As was then

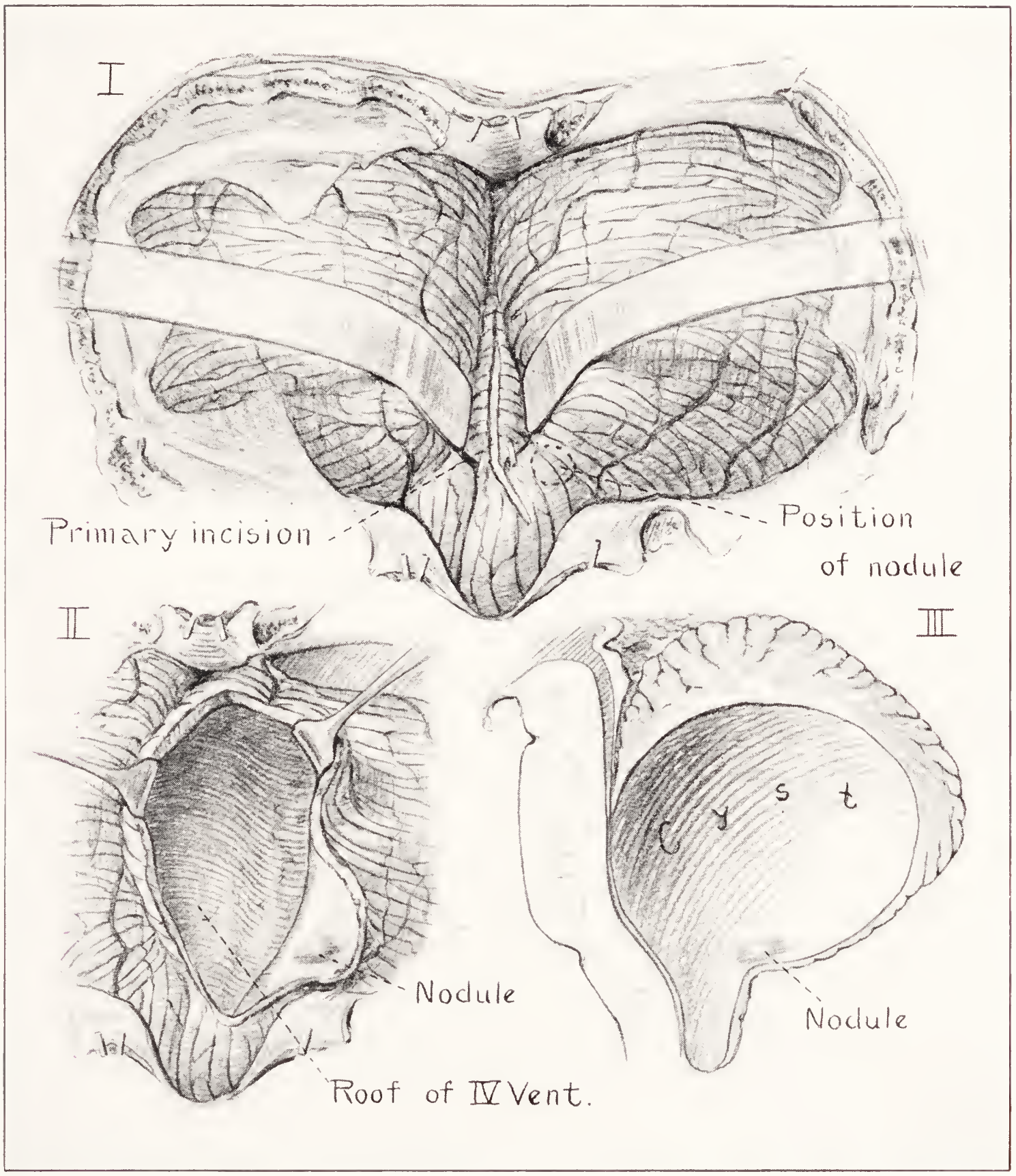

FIG. 93. Sketches of operative procedure in case cited with large, *circa* 130 cc. right cerebellar cyst containing minute angiomatous nodule.

pointed out, many of these tumours had in the past been mistaken for "vascular gliomas" from which, however, they may be readily distinguished by histological methods for staining reticulin. Whereas the angiomatous malformations are chiefly found in the cerebrum, the true angioblastic tumours in our series (once mistakenly called peritheliomas) only occur in the cerebellum and in one instance Lindau's important disclosure of their relation to angiomatosis of the retina was incidentally confirmed.[84] Twelve additional cerebellar hemangioblastomas (making 25 in all) may now be recorded, two of them having been newly detected in the process of histologically reinvestigating the cerebellar astrocytomas.

Though blood vessel tumours represent only 2 per cent of intracranial tumours as a whole, they nevertheless have features of peculiar interest and fairly definite views regarding the method of treating them can be formulated. The vascular malformations, whether purely venous or arteriovenous, should be treated by radiation rather than by an attempt to excise them. Even when an audible bruit betrays an arteriovenous communication, this may disappear and all symptoms subside after radiation. This effect of the rays apparently so damages the endothelium of the vessels as to cause their thrombosis and obliteration. An example was given in our 1928 monograph cited above[83] (Case XIV) and she now (1931), six years since the first onset of her audible bruit, is symptom-free as a result of radiation alone.

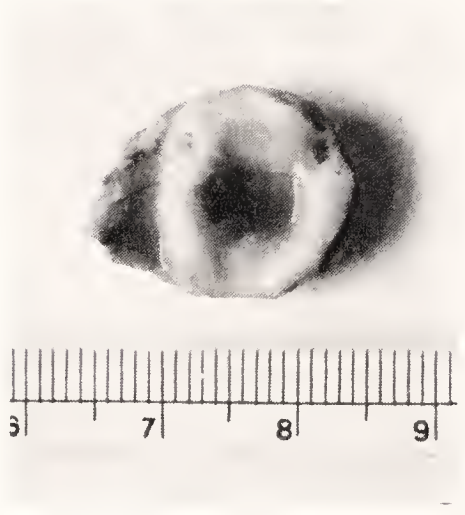

FIG. 94. Block of tissue from wall of cerebellar cyst; at dark centre is the 5-mm. mural nodule.

When a cystic tumour of the cerebellum of whatsoever sort is encountered the mural nodule should be sought for and when identified completely enucleated; whether the lesion will prove to be an astrocytoma or an angioblastoma cannot always be foretold by naked eye appearances but the chances are greatly in favour of the former. If a total removal is not accomplished, the cysts rapidly refill and the tumour may attain a large size. With extirpation of the mural nodule, on the other hand, at the primary session, experience has shown that a permanent recovery may ensue. A mural angioblastoma may be extremely small and easily escape detection—indeed they may be so microscopic in size as to require serial sections of the cyst wall for their identification. The following is an example of a small lesion:

A Jewish attorney, 33 years of age (Surgical No. 37620) was first admitted *November 7, 1930,* with the complaint of periodic dizziness, morning nausea with vomiting, constipation, and suboccipital pain on straining at stool—all of ten

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[83] Cushing and Bailey: Tumors arising from the blood-vessels of the brain: Angiomatous malformations and hemangioblastomas. Charles C Thomas, Pub., Springfield, Ill., 1928, 219 pp.

[84] Cushing and Bailey: Hemangiomas of cerebellum and retina (Lindau's disease). Arch. Ophth., 1928, LVII, 447–463.

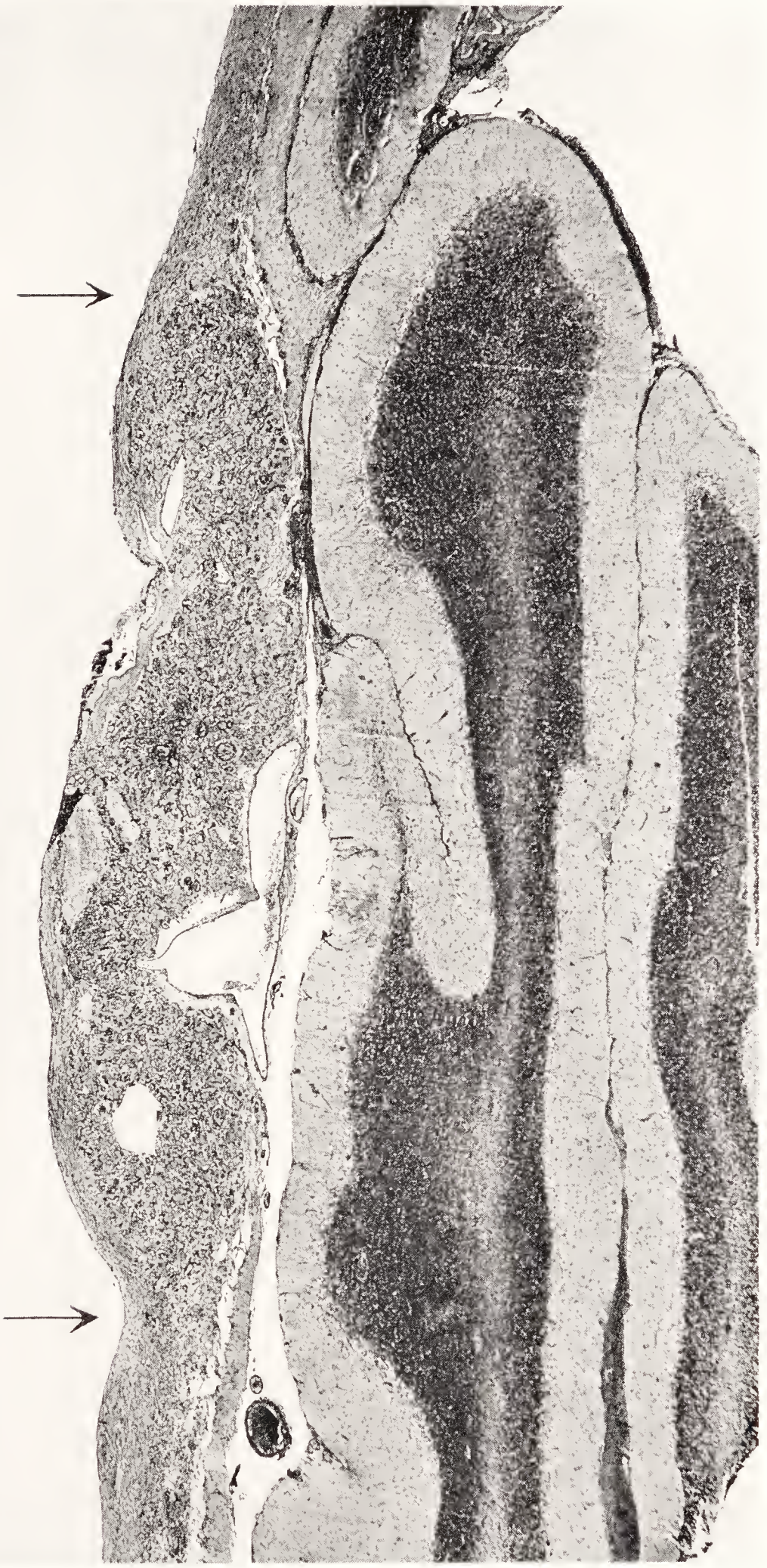
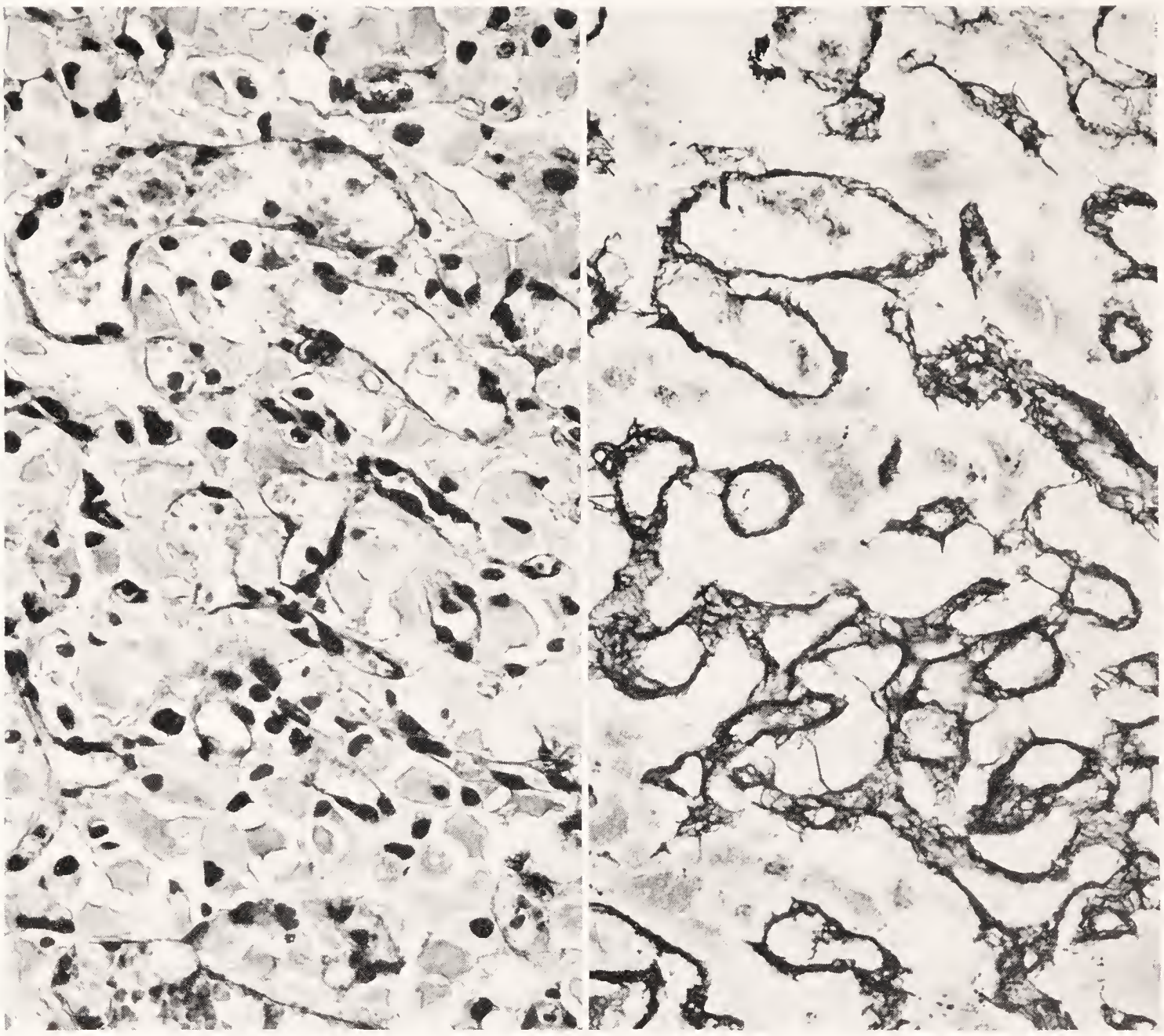


FIG. 95. Showing (between arrows) mid-section of the entire mural haemangioblastoma (*cf.* Figs. 93, 94) in wall of large cerebellar cyst. Overlying leaflets of cerebellum shown to the right (hematoxylin and eosin, ×18).

weeks' duration. He had been treated by colonic irrigations on the basis of a possible toxic disorder.

Physical examination was entirely negative apart from slight nystagmus, and as a "tumour suspect: question labyrinthitis" he was discharged after a week's sojourn.

In the course of the next two months a typical cerebellar-tumour syndrome rapidly developed and on his readmission, *January 26, 1931*, there was an acute choked disc of 4 diopters, frequent projectile vomiting, diplopia and marked cerebellar ataxia with positive Romberg and staggering gait.



FIGS. 96, 97. Sections of tumour in Fig. 95, to show: (left) the typical architecture of an haemangioblastoma (hematoxylin and eosin, ×300); and (right) the same, with interstitial tissue alone stained (Perdrau, ×300).

On *February 6*, under novocain anaesthesia the usual suboccipital exploration disclosed (Fig. 93) a large median cerebellar xanthochromic cyst. A minute mural nodule the size of a split pea (Figs. 94, 95) was finally identified in the upper wall of the cyst at about the junction of tonsil and left hemisphere. This was excised together with the thin overlying cortex. A presumptive diagnosis of hemangioblastoma was made by supravital examination and this was corroborated on fixed-tissue sections (Figs. 96, 97).

Recovery from this operation was rapid and the patient was discharged

February 28, in excellent condition apart from some residual loss of visual acuity on subsidence of the choked discs—an unfortunate consequence of our inability to make a correct diagnosis at the first admission.

The cerebellar hemangioblastomas which are unassociated with cysts may have scanty or excessive collateral vascularity. When the vascularity is slight, even a large tumour may be successfully enucleated usually under the impression that it is an astrocytoma, its true histological nature coming as a surprise. On the other hand, the tumours may be associated with such a formidable degree of vascularity the attempt even to take tissue for verification would be regarded as foolhardy. It is in these truly desperate cases that electro-dessicating procedures may prove most helpful, but at best the surgical removal of one of these tumours is attended with the greatest possible hazard. It is the predominance of cases of the latter type that largely accounts for the high operative mortality in the series.

Statistics.—One of the 25 tumours was verified at autopsy without preceding operation. On the remaining 24 cases, 44 operations have been performed with 6 fatalities, giving a case-mortality of 25.0 per cent and an operative mortality of 13.6 per cent, thus showing a slight improvement over the 36.4 per cent and 18.2 per cent cited in our monograph three years ago. The secondary operations have always been desperate procedures representing serial attacks on recurrent lesions, four operations having been undertaken in each of four patients, two of whom succumbed after the last procedure.

In the recent three-year period 7 patients have been operated upon 10 times with a single fatality giving a 14.3 per cent case- and a 10 per cent operative mortality.

IX. Sarcomas

Whereas sarcomas of the brain were formerly thought to be common, the majority of cases once so diagnosed are now known to have been either true gliomas or the more malignant types of rapidly growing meningiomata. There are several tumours, in the Brigham collection, among those we have so far hesitated to classify, which a number of pathologists in years gone by have diagnosed as sarcomas. Some of them are large, solid tumours which have been cleanly enucleated with no sign of recurrence after an interval of years so that their life history does not accord with that of a sarcoma. They consequently have been put among the indeterminate miscellaneous tumours awaiting further study.

There however are 14 other tumours in the series which have definitely been diagnosed as sarcomata, a report upon seven of them having been made by Dr. Bailey, who, in discussing the theory of their histogenesis,[85] admits that they are of interest chiefly from the standpoint of theoretical pathology. Four of Dr. Bailey's seven cases were malignant tumours apparently arising from the pia arachnoid and its perivascular prolongations; two were fibrosarcomatous lesions which I personally would prefer to classify as meningiomas of sarcomatous type; and the last was an alveolar sarcoma, possibly metastatic. The additional seven cases include: (1) a case of "sarcomatosis of the brain" reported from the clinic by B. M. Fried;[86] (2) a diffuse perithelial sarcoma in the brain of an infant thought clinically to have a cerebellar medulloblastoma and reported with C. L. Connor[87] chiefly from interest in the fact that the widespread invasion of the meninges was invisible to the naked eye; (3) another perithelial or perivascular sarcoma arising in the tubero-infundibular region fully described by Fulton and Bailey[36] in one of their papers on tumours of the third ventricle; (4, 5 & 6) three recently identified sarcomas involving the optic chiasm; and finally (7) a remarkable early case in the series, the story of which follows:

The patient, a boy 5 years of age, was admitted to the Johns Hopkins Hospital (Surgical No. 16946) on *November 7, 1904*. The ninth of ten notably healthy and active children, he began five months prior to admission to have nocturnal headaches which were followed ere long by bouts of vomiting. A month later he began to show lameness, first of the left leg and then of the left arm, which progressed to a hemiplegia. He soon began to have periods of stupor; and for nine days convulsive spasms in the paralyzed limbs and corresponding side of the face had been observed. During his illness he had lost much weight.

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[85] Bailey, P. Intracranial sarcomatous tumors of leptomeningeal origin. Arch. Surg., 1929, XVIII, 1359–1402.

[86] Sarcomatosis of the brain. Arch. Neurol. & Psychiat., 1926, XV, 205–217.

[87] Diffuse tumours of the leptomeninges. Two cases in which the process was revealed only by the microscope. Arch. Path. & Lab. Med., 1927, III, 374–392.

[36] Loc. cit., Case II.

Examination.—This showed a deeply comatose, ill nourished child with an enlarged head more prominent on the right side.* Percussion gave a definite

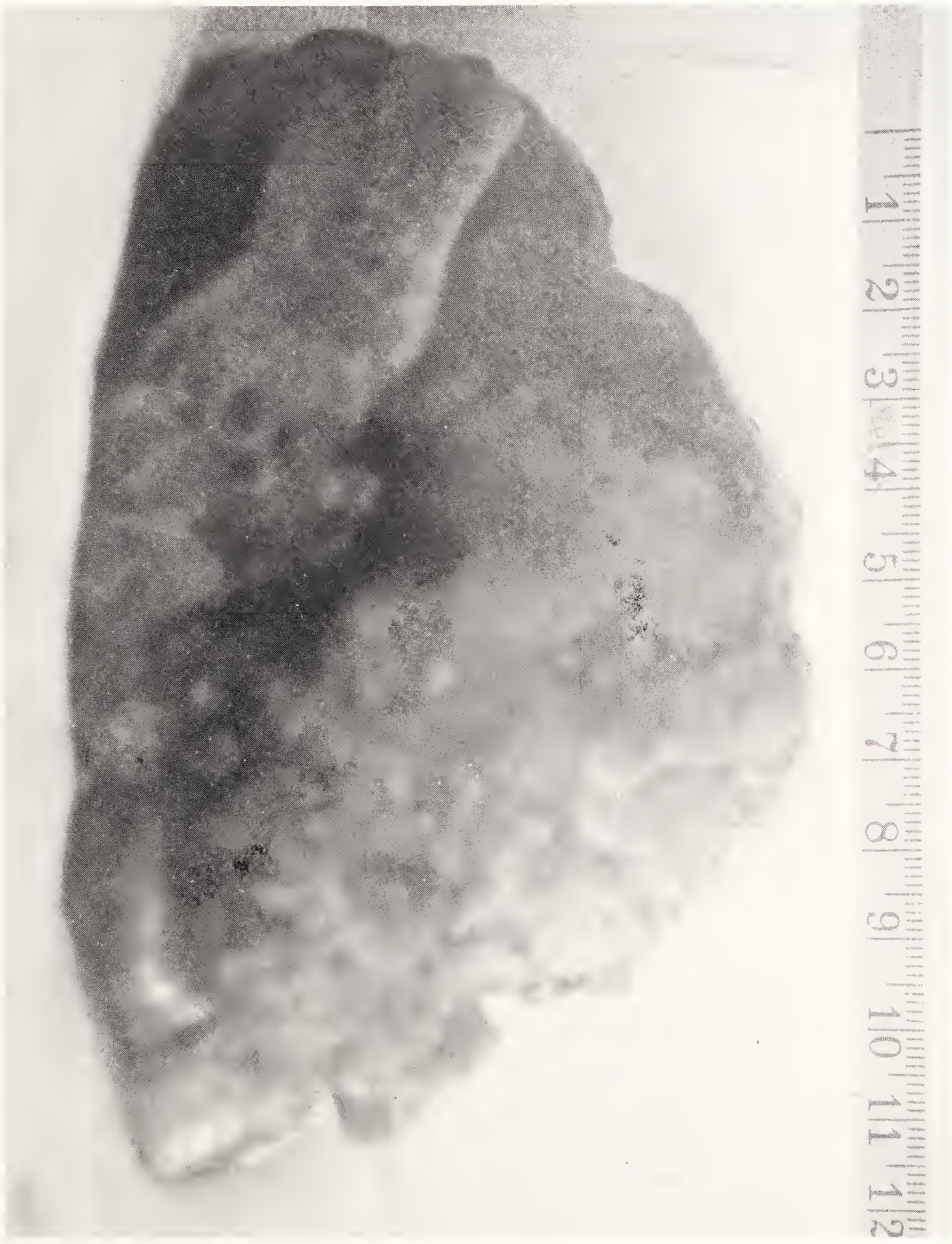

FIG. 98. Showing (despite the poor negative) the size of the 341-gram enucleable tumour, long classified as a sarcoma.

* Cranial X-ray plates were not routinely taken in 1904 and as some few of these early tumours are not preserved in the writer's collection it is now impossible to say whether the growth showed calcific tendencies.

Macewen note and to palpation, not only were the sutures widely spread, but areas of cranial tabes were apparent. The eyes were prominent, the pupils dilated without reaction to light, and there was an internal squint. The left fundus oculi was normal in appearance, the right showing a low grade of papilloedema.

There was marked spastic rigidity of the left leg and a flaccid paralysis of the arm. At frequent intervals there occurred definite Jacksonian seizures beginning in the muscles of the left eye and spreading slowly to the lower face, ear, neck, shoulder and arm and lasting from three to five minutes. There was a bilateral active Babinski plantar reflex. The child's temperature was markedly subnormal. He was unable to take nourishment.

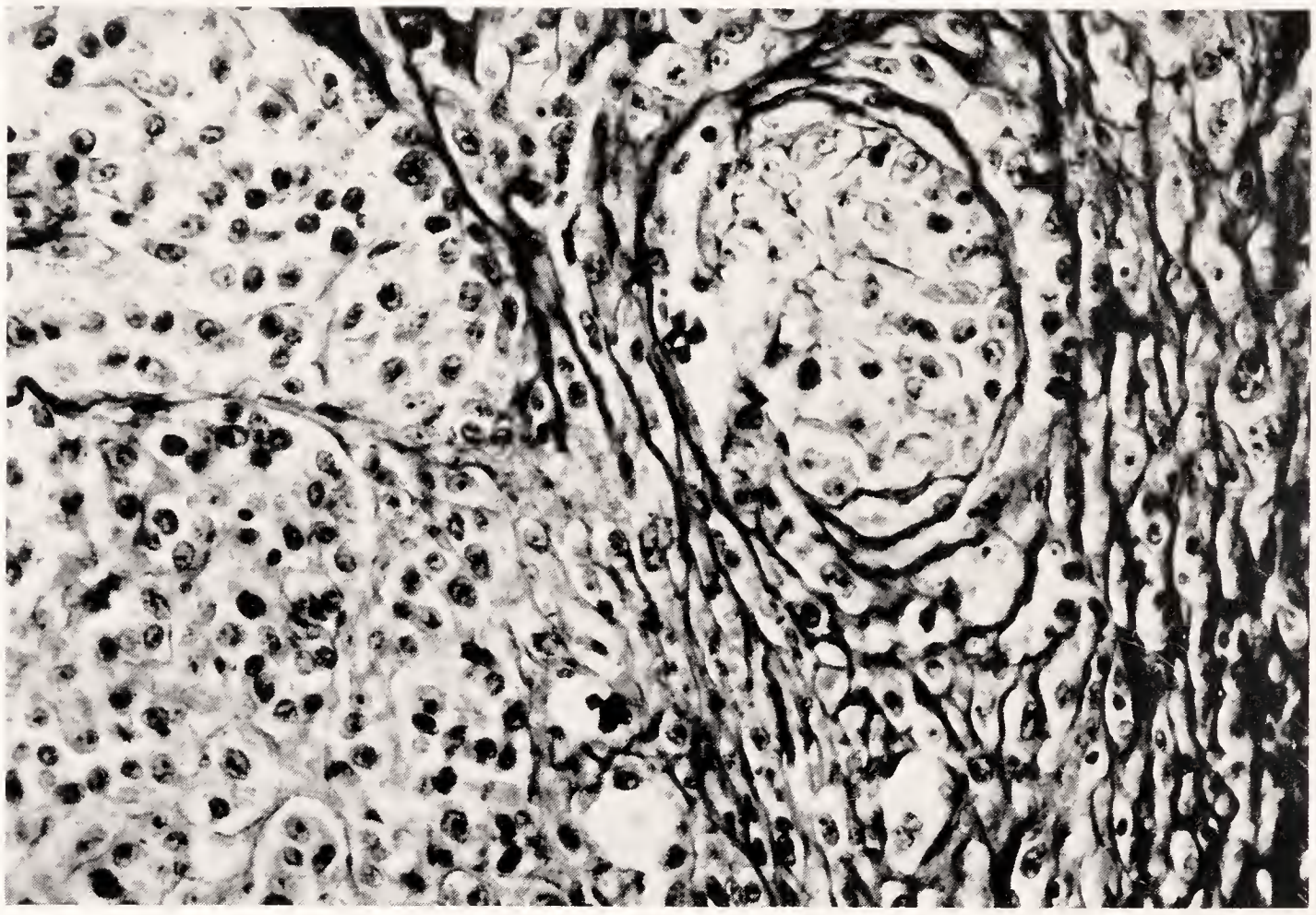

FIG. 99. Section from the large tumour shown in Fig. 98. Note alveolar arrangement of cells and intercellular strands of connective tissue (phosphotungstic acid hematoxylin eosin, ×300).

Operation.—Though the boy's condition was desperate, an operation was undertaken two days after admission. Under ether anaesthesia a large right-sided osteoplastic flap under a tourniquet was turned down with considerable loss of blood from the scalp. The bones were exceedingly thin, largely absorbed, and the sutures widely separated. An exceedingly tense atrophic dura was exposed which proved to be adherent in the parietal region to a firm underlying tumour. On reflecting the dura this growth, together with the adjacent thin overlying cortex, promptly extruded so markedly that wound closure for a second session, which would have been highly desirable in view of the child's condition, would have been impossible. There was no recourse other than to brush the cortex away from the firm nodular tumour which proved to be of unexpected size and which was finally lifted out of its bed by finger dissection. Fortunately the mass came away intact without loss of blood, but at the moment of its final

dislodgment there was a sudden respiratory cessation and all efforts at resuscitation were unavailing.

An examination of the brain made a few hours after death showed that the whole posterior falx had been laid bare and the lateral ventricle had been opened. There however had been no bleeding into the ventricle to account for the sudden respiratory failure. Whether this operation might

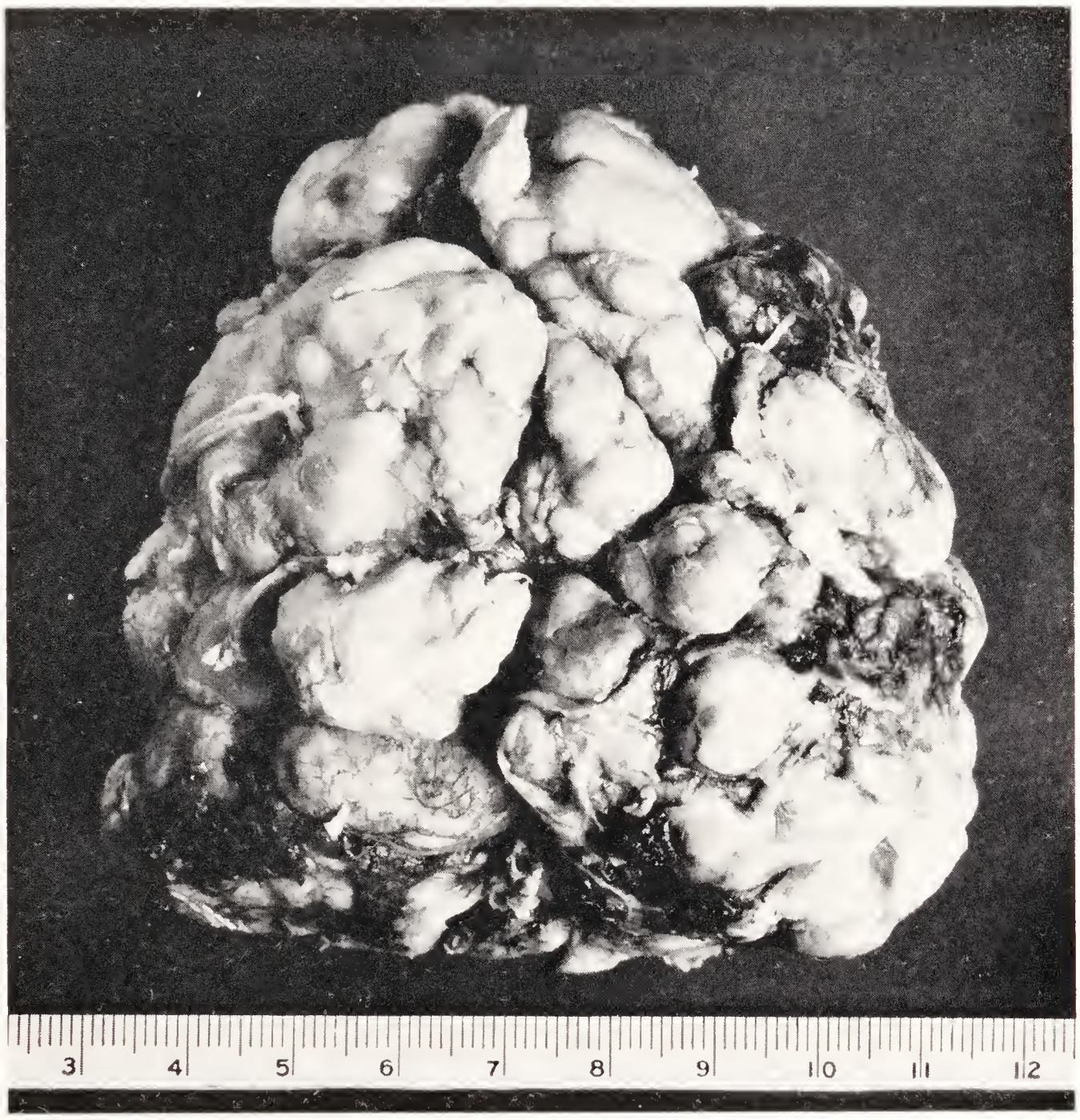

FIG. 100. Photograph of a 273-gram tumour, supposedly a fibrosarcoma, removed from the brain of a child four years of age without recurrence after five years.

have been safely carried through at the present day with a more highly perfected operative technique is impossible to say.

The tumour (Fig. 98), one of the largest in the series, weighed 341 grams. The histopathological diagnosis at the time lay between a round celled sarcoma and a fibromyxosarcoma (Fig. 99). Five years later the growth, together with other tumours in the collection, was histologically restudied by Dr. Charles Lambert who concluded that it was a glioma, small islets of spider cells (astrocytes) with tinctorially differentiated

fibrils being demonstrable. The gross specimen unfortunately has not been preserved so that further differential studies are impossible; but the original sections show a cellular growth with an abundant intercellular connective tissue evident on Perdrau's stain.

The lesion therefore may well be regarded as a sarcoma and it remains so classified though there are other large tumours of highly similar sort which still remain in our unclassified list, as will be told. One or two of these tumours have similarly been removed from the cerebral hemispheres of children with recovery and have shown no tendency to recur though they were diagnosed at the time of removal as probable sarcomas of the

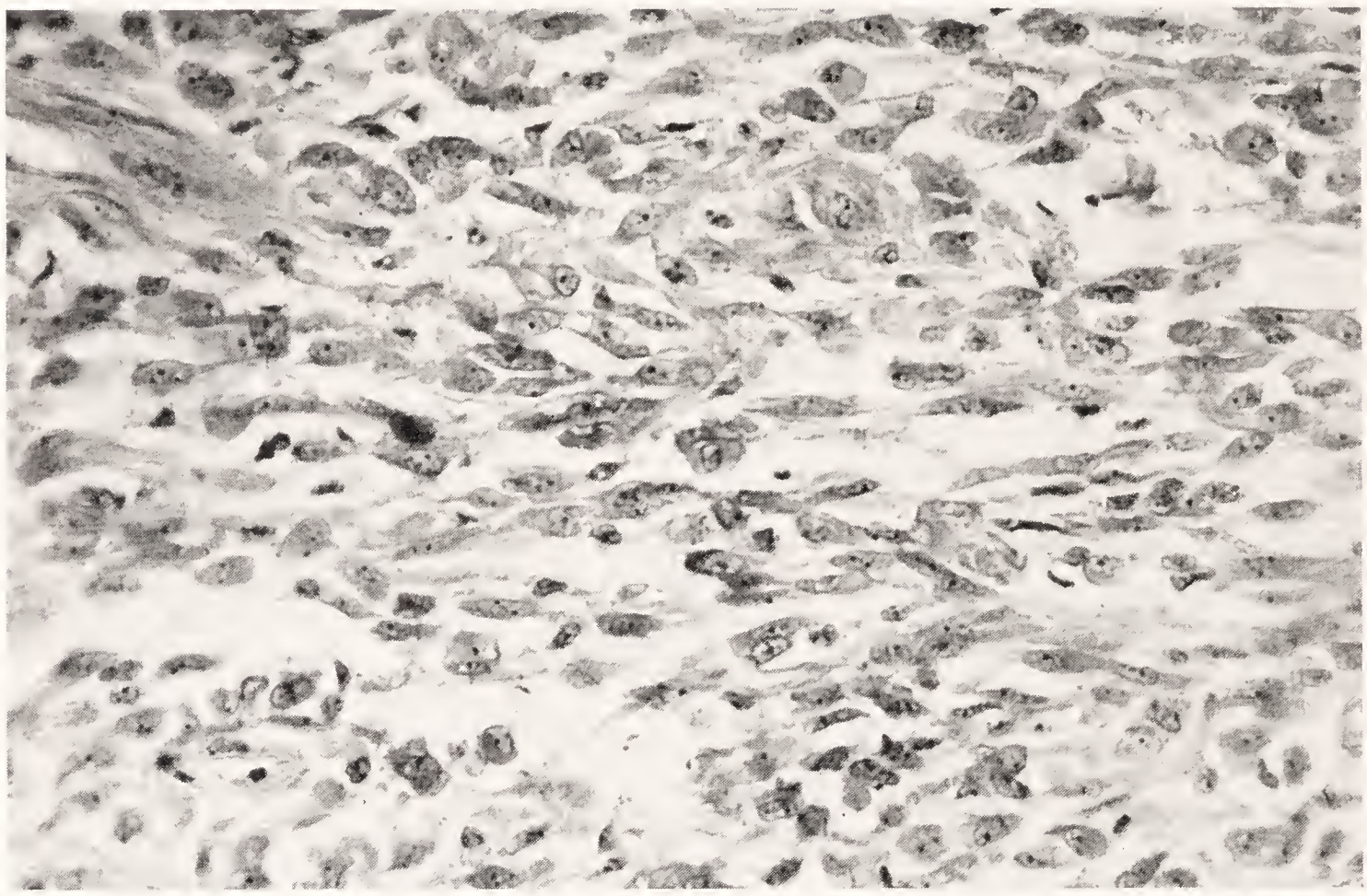

FIG. 101. Showing (phosphotungstic acid hematoxylin, ×300) the general character of the tumour shown in Fig. 100 and taken to be a fibrosarcoma.

brain. One of them was an enucleable 273-gram tumour (Fig. 100), which has been elsewhere described,[81] (Case 1), was called an ependymoblastoma by the pathologists but we regard it as a fibrosarcoma (Fig. 101) because of the abundant connective tissue. The child from whose brain this large tumour was removed, now five years later, continues in perfect health. These large, enucleable sarcomas of the brain in children undoubtedly need further study.

Statistics.—One of the patients in this series of 14 "sarcomas" died after ventriculography, one soon after admission without operation, and the 17 operations on the remaining 12 patients led to six fatalities, giving a 50 per cent case- mortality and a 35.3 per cent operative mortality. The tumours are too variable in type to give any particular significance to these figures.

X. Papillomas of the Choroid Plexus

A report on the six papillomas, observed in our first *circa* 1,000 verified tumours, was made in 1925 in collaboration with Loyal Davis.[88] Six additional examples have been verified in the subsequent 1,000 cases, so that their numerical incidence of 0.5 per cent remains unchanged.

In nine instances the tumour has been found in the posterior fossa; six of them were midline tumours of the fourth ventricle, and the other three were laterally disposed lesions clinically mistaken for acoustic tumours,* the point of origin probably having been from the choroidal tuft at the foramen of Luschka. Most of these nine tumours have been solid, cauliflower-like affairs without associated cyst formation. In illustration:

An unmarried Polish woman 22 years of age first entered the hospital on the Medical Service on *April 1, 1926*, and was promptly transferred (Surgical No. 26094) with a presumptive diagnosis of cerebellar abscess. She had been struck by an automobile two years before admission but not until six weeks previously had she begun to have severe headaches which had obliged her to stop work. A sudden increase in her cephalalgia with vomiting and slight fever led to her hospital admission.

She was disoriented, incontinent and stuporous with nystagmus and marked instability when put on her feet. She had a high grade of choked disc.

Under local anaesthesia a suboccipital exploration was made by my assistant who found normal-appearing hemispheres though considerable foraminal herniation of the left tonsil was noted. A needle was introduced into the left hemisphere and at a depth of 4 cm. a small cyst containing clotting xanthochromic fluid was evacuated. An incision was made across the hemisphere down to the cyst which was opened; a grayish red tumour was seen but as it appeared to be highly vascular it was left untouched.

From this operation the patient made a good recovery and was finally discharged from the hospital on *May 4, 1926*, after a series of X-ray treatments. She was kept under observation for the next five years during which time she was able to keep at her work as a telephone operator.

Owing to a return, early in *1931*, of her former headaches and vomiting accompanied by a renewed choking of the discs, she was advised to reënter the hospital. She meanwhile, in addition to considerable ataxia, had developed palsies of the right abducens and facial nerves, marked dysarthria and dysphagia, together with weakness of the left arm and leg. It was thought that the tumour, previously tabulated as "gliomatous cyst unclassified" would prove to be an astrocytoma which had come to involve the pons and brain stem.

At this second operation, *January 30, 1931*, a median incision was made through the vermis disclosing a firm tumour the size of a walnut which had a

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[88] Papillomas of the choroid plexus, with the report of six cases. Arch. Neurol. & Psychiat., 1925; XIII, 681–710.

* An example of this is given in "Tumors of the Nervus Acusticus,"[57] 1917, Case 35, page 226.

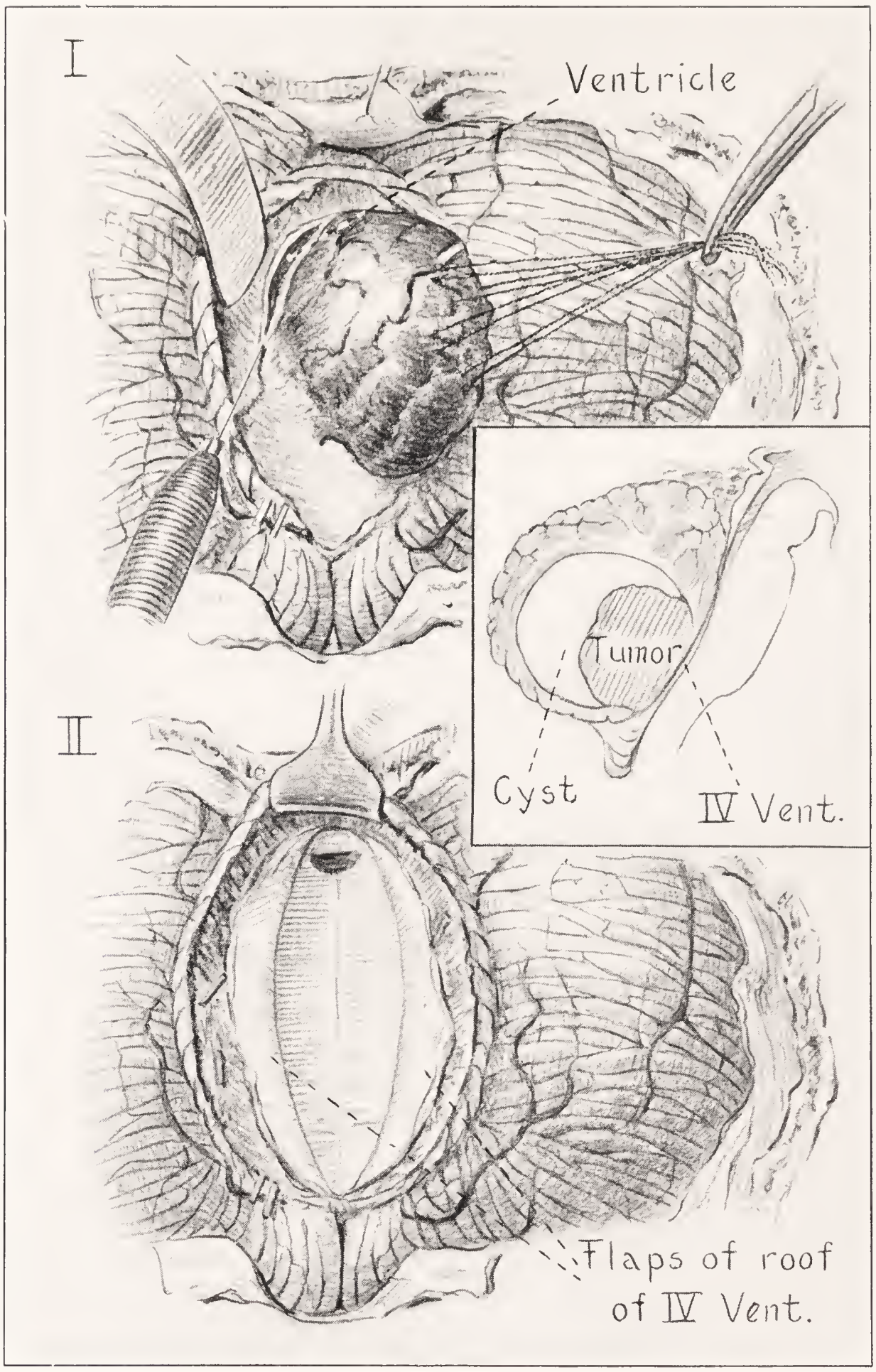


FIG. 102. Sketches showing removal in case cited of papilloma of IVth ventricle (*cf.* Fig. 103).

granular reddish surface and was evidently a papilloma. It was removed intact (Figs. 102, 103) together with the roof of the IVth ventricle to which it was attached. Subsequent sections confirmed the operative diagnosis (Fig. 104).

From this procedure the patient made a slow recovery with tardy and incomplete restoration of function in the preoperatively paralyzed nerves.

At the present writing, six months later, her general condition is greatly improved though she is still somewhat unsteady and some residual palsies are present.

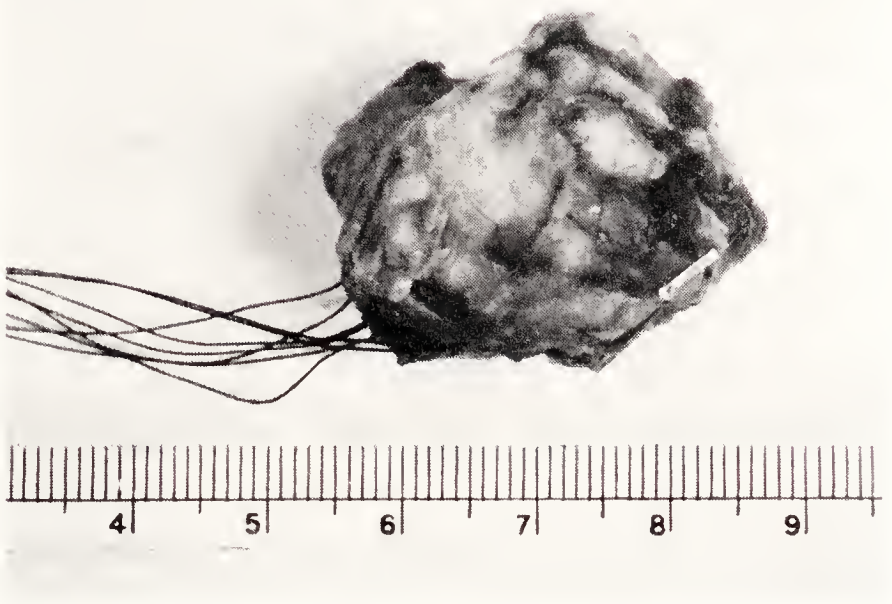


FIG. 103. Papilloma of choroid plexus of IVth ventricle (nat. size) after removal.

The three recorded papillomas of the cerebrum, unlike the subtentorial lesions, were associated with large cysts of the lateral ventricles.

Statistics.—The tumour in one of the twelve cases was verified at autopsy without operation. In the 11 surgically treated cases, 23 operations were performed with 3 fatalities, giving a 27.3 per cent case-mortality and a 13.4 per cent operative mortality.

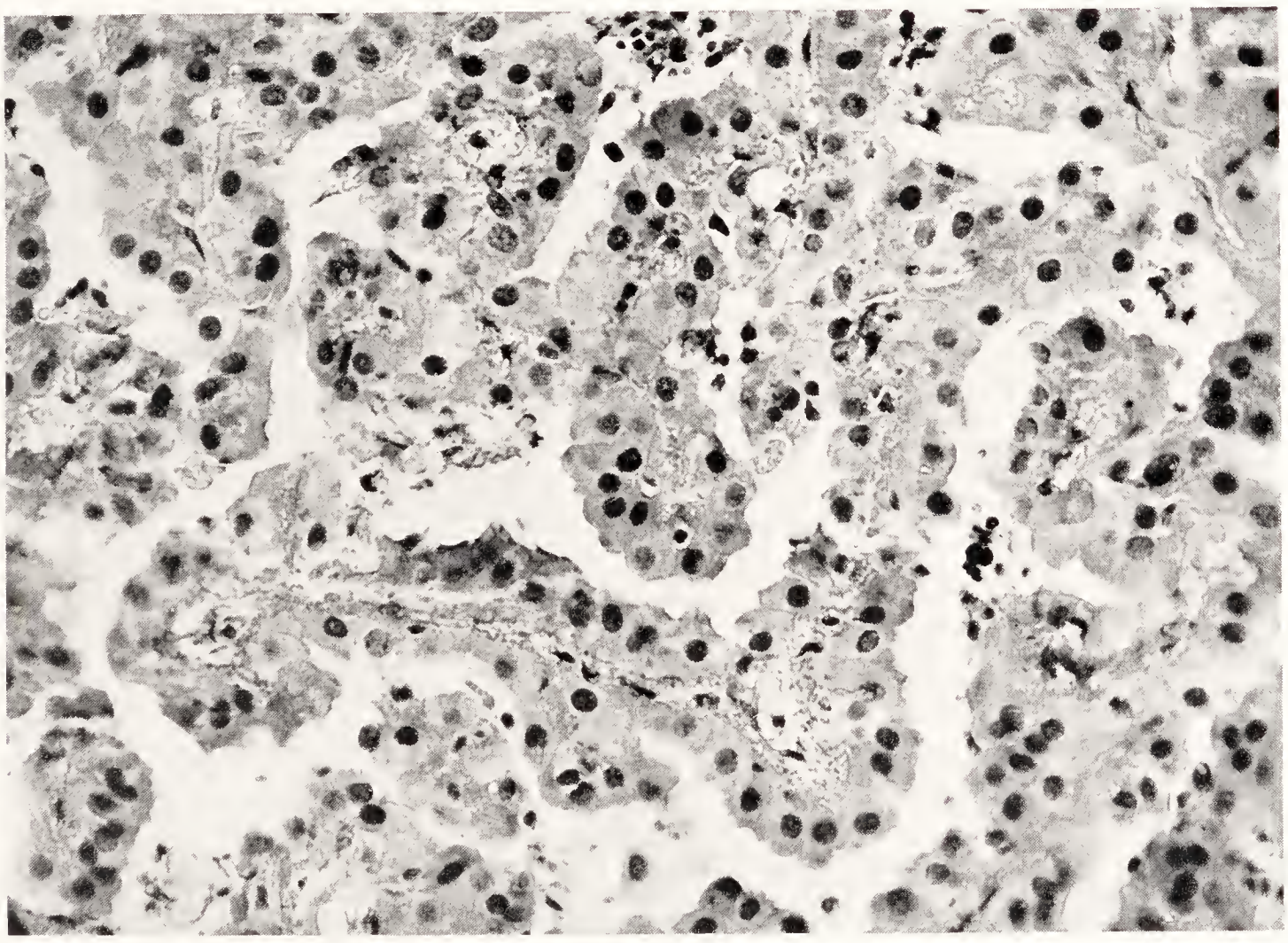
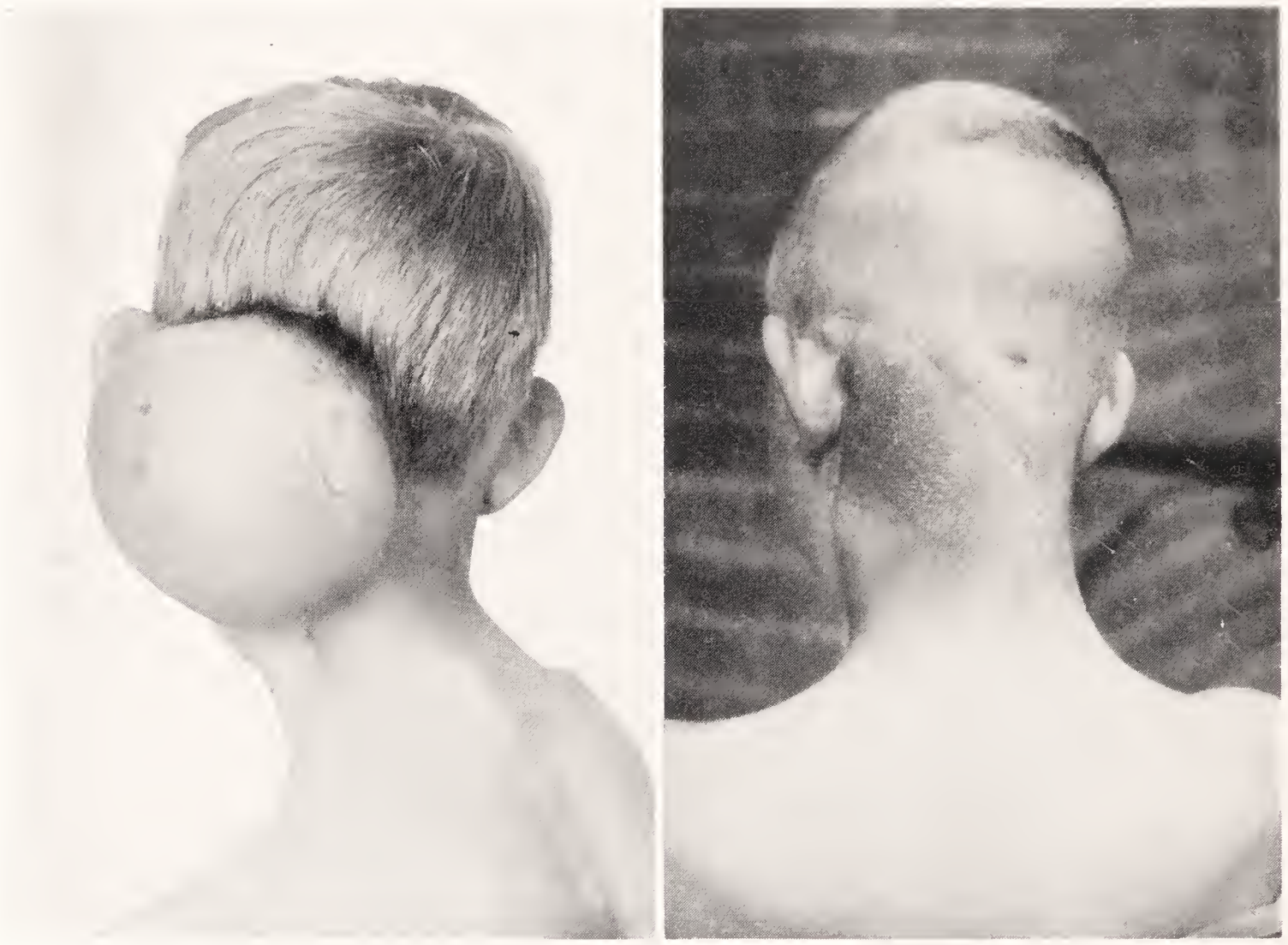


FIG. 104. Fixed-tissue preparation of typical papilloma of choroid plexus cited in text (hematoxylin and eosin, ×300).

XI. Miscellaneous Tumours

Under this caption we have from time to time permitted tumours of divers kinds to gravitate. The group as it at present stands contains: (1) Cysts which had caused tumour symptoms (with the exclusion of occasional traumatic and porencephalic cysts which are included under "tumour suspects"); (2) Certain cranial osteomas which have secondarily affected the brain; and (3) A miscellany of unclassified tumours about whose nature there is still great uncertainty.



Figs. 105, 106. Large osteoma of occipital bone causing left cerebellar symptomatology (J. H. H. Surgical No. 24104).

The Cysts.—These are six in number. Two of them were of indeterminate nature; two were echinococcal and multiple; and two were cysts of the choroid plexus which had led to unilateral hydrocephalus from obstruction of the foramen of Monro. In this series of 6 cases, there were 11 operations with 3 fatalities.

The Osteomas.—These have all been tumours which have caused intracranial symptoms by compression, invasion, or by other complicating factors. Three of them were haemangiomas of the cranial vault, one of

which has been described in print.[89] One was an adamantinoma of the mandible which had grown through the skull; three were osteochondromas of the cranial base projecting up into the cranial chamber; six were osteomas of the skull, some of them of large size (*cf.* Figs. 105, 106); and eight were orbito-ethmoidal osteomas. Four of the tumours of the latter sort, with the sometimes astonishing intracranial complications to which they may lead the writer has described elsewhere.[90]

In this series of 21 miscellaneous osteomas, there have been 29 operations with a single fatality.

The Unclassified Tumours.—Seventeen in number, these tumours represent a group of lesions of great interest if for no other reason than that there has been no unanimity of opinion concerning their nature. In illustration of this:

A woman 27 years of age (Surgical No. 23802) was first admitted in *May 1925* with a history of epileptiform attacks. In spite of a "pineal shift" to the right, tumour was not suspected and she was discharged without operation. A year later, when she was again seen, there was no change in her condition. She meanwhile had married and had borne a healthy child. In *February 1928*, she was found to have a slight right lower facial weakness and early speech defect. A diagnosis of probable tumour of the left temporal lobe was made and she was advised to reënter the hospital for operation. This advice was not taken and three months elapsed before she was admitted to the hospital in a comatose condition. She was brought out of this state by hypertonic saline injections and it was then possible to take her fields of vision which showed a right homonymous hemianopsia sparing the macula. The diagnosis of a probable left temporal lobe astrocytoma was made in view of the long-standing history.

At operation on *May 14, 1928*, a large temporal tumour thought at the time to be a fibrillary astrocytoma was radically extirpated by electro-surgical methods, a practically complete lobectomy having been performed. When the fresh tissue was examined by Dr. Bailey it was found to be composed of rounded cells with abundant cytoplasm and no fibrillae suggesting a metastatic sarcoma. A later report from the pathological laboratory described a highly cellular tumour with occasional mitoses, and though there was no tendency to calcification a diagnosis of (query) vascular oligodendroglioma was made. Additional blocks from the tumour, subsequently cut and studied have been variously diagnosed as a growth originating from the choroid plexus, possible ependymoma, possible hypernephroma. The patient was given a series of X-ray treatments. She died at her home, evidently with local recurrence, on *March 24, 1930*, six years from the onset of symptoms.

Another of these unclassified tumours has been variously regarded at several hands as possible spongioblastoma, sarcoma, neuroblastoma and angioma. Not only have these tumours been most unusual in their histological appearance, but some of them have been no less remarkable from a surgical standpoint. Of this an example may be given:

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[89] Surgical end-results in general, with a case of cavernous haemangioma of the skull in particular. Surg., Gynec. & Obst., 1923, XXXVI, 303–308.

[90] Experiences with orbito-ethmoidal osteomata having intracranial complications. Surg., Gynec. & Obst., 1927, XLIV, 721–742.

A young man 17 years of age (Surgical No. 30242) first entered the hospital in *December 1927* with a history of having had convulsive attacks for over four years, generalized in nature. He was found to have a high grade of choked disc, a right-sided anosmia and a left hemiparesis. A right osteoplastic exploration was made by Dr. Horrax who found and removed a large subcortical tumour (Fig. 107) from the pre-central region. It was necessary two days later to re-elevate the flap owing to a clot. Following these operations the patient made a nigh perfect recovery and was discharged on *January 5, 1928*, unfortunately without a postoperative series of X-ray treatments.

The tumour when examined in the fresh proved to be composed of small round cells with very little cytoplasm enclosed in an abundant meshwork of

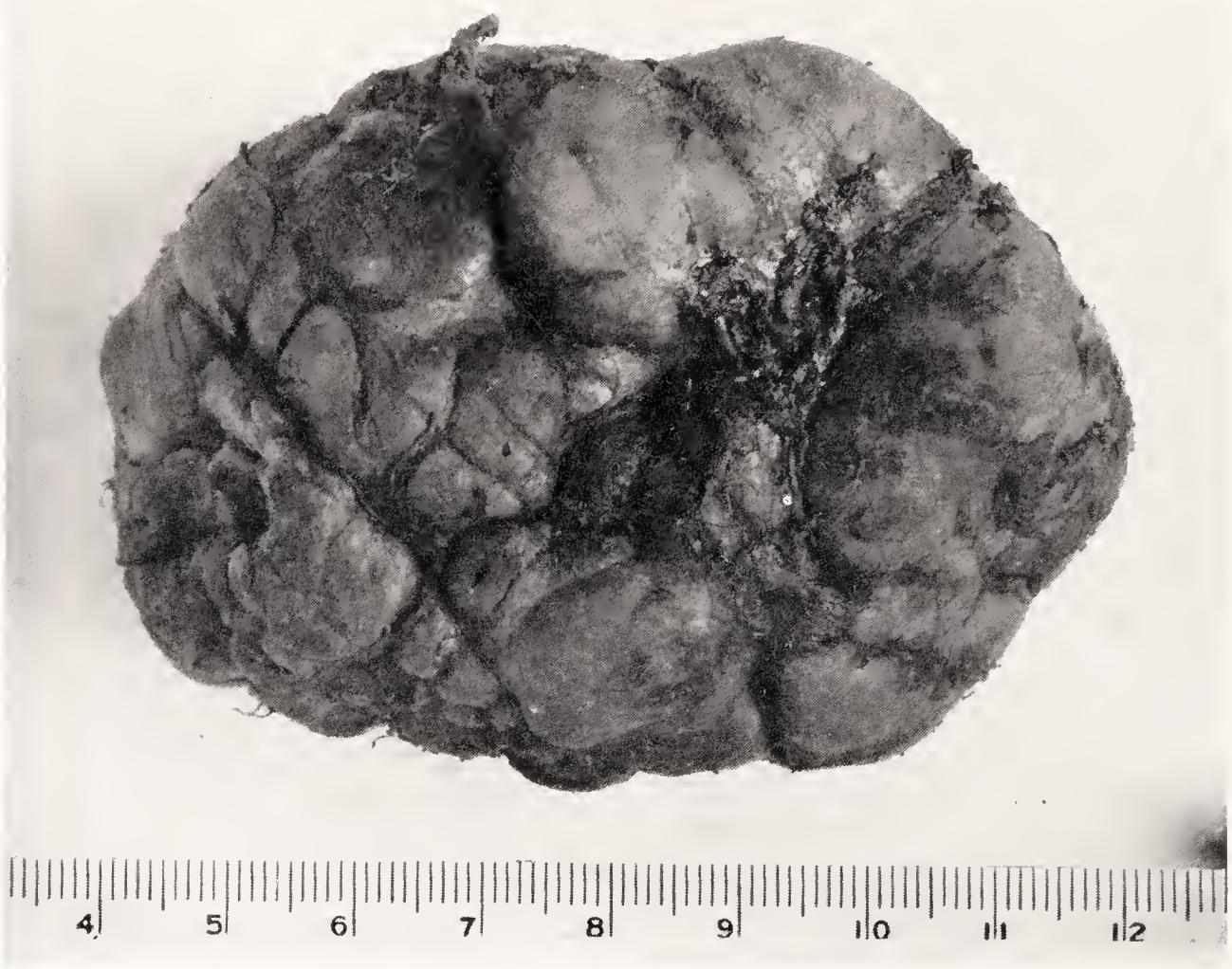

FIG. 107. Showing (nat. size) the tumour regarded as a sarcoma removed at the first operation.

fibroblasts and was thought to be a small-round-cell sarcoma. When fixed-tissue sections came to be studied in the pathological laboratory, they were first reported as a medulloblastoma, this diagnosis, later on, being changed to "alveolar sarcoma, possibly metastatic." Subsequently when an abundance of reticulin fibrils were disclosed the lesion was listed as unclassifiable.

The patient returned to his work as a garage mechanic soon after his discharge and continued well for three months when he began having occasional convulsive attacks owing to which he finally reëntered the hospital on *January 15, 1929*. He was not thought to have any signs of recurrence of tumour at this time and was put on a luminal régime. Before a month had passed, he began having headaches and finally a definite palsy in his left side coming on after a severe epileptiform seizure led to his readmission on *February 25, 1929*.

At this time evidence of recurrence was unmistakable; there was a definite left hemiparesis with hyperactive deep reflexes, mental obscuration, and a return of the choked disc.

On *March 1*, under local anaesthesia, a third operation was performed. When the flap was reflected, two pea-sized nodules were found and electrically removed from the under surface of the dura, evidently "seeded" tumour. A huge

FIG. 108. Large recurrent cystic sarcoma (nat. size) removed at second session (*cf.* Fig. 107) after 14-months interval.

partly cystic, definitely encapsulated lesion (Fig. 108) occupying the entire right frontal region was then carefully dissected out by electro-surgical methods. When this cystic mass had been enucleated, another large, irregular-shaped solid growth (Fig. 109) was disclosed lying directly under it, the two tumours being definitely separated from each other by a thin film of cerebral tissue. The anterior horn of the ventricle was widely opened in the process of its removal. There was a good deal of bleeding controlled by clips. A small gutta percha tissue drain was left leading from the depth of the wound.

The patient did well for the first nine days when, because of a suspicion that a hematoma might have formed, the flap was reelevated and a large amount of bloody fluid and fibrinoplastic exudate were sucked out of the tumour cavity together with considerable clot. There was prompt improvement. Radiotherapy was given and he was discharged *April 18, 1929*, in surprisingly good condition.

Reëxamination of the tumour by various methods added nothing new. It showed abundant mitoses and was looked upon by everyone as a growth of mesenchymal origin, probably a perithelial sarcoma.

FIG. 109. Showing (nat. size) the separate tumour, in addition to that in Fig. 108, as removed at the second operation, the layer of cortex separating the two lesions being apparent on the exposed surface.

To make a long story short, the patient did well for a time in spite of occasional Jacksonian seizures in the left fingers and arm. Evidence of recurrence was apparent before six months had passed, and on *September 9, 1929*, the bone-flap was for the fifth time reëlevated by Dr. Horrax who found a wide-spread, multilobular, recurrent tumour at the previous site. Though several separate tumour masses were enucleated, some of them partly cystic, no attempt was made at this last session to do more than to remove enough of the neoplastic tissue to permit the scalp to be replaced after sacrificing the cranial portion of the flap.

Though the patient was in good condition when discharged, and though X-ray therapy was persisted in, he went rapidly down hill and his death was reported as having occurred a month later without postmortem examination.

The history of the tumour covered a period of six years from the onset of symptoms.

The conclusion should not be drawn, from these examples given above, that the majority of the 17 as-yet-unclassified tumours have been looked upon as possible or probable true sarcomas of the brain which might well enough have been transferred to the group of cases assembled in Section IX. Other growths of equally unusual type and no less uncertain composition have sedimented in this temporarily indeterminate collection of

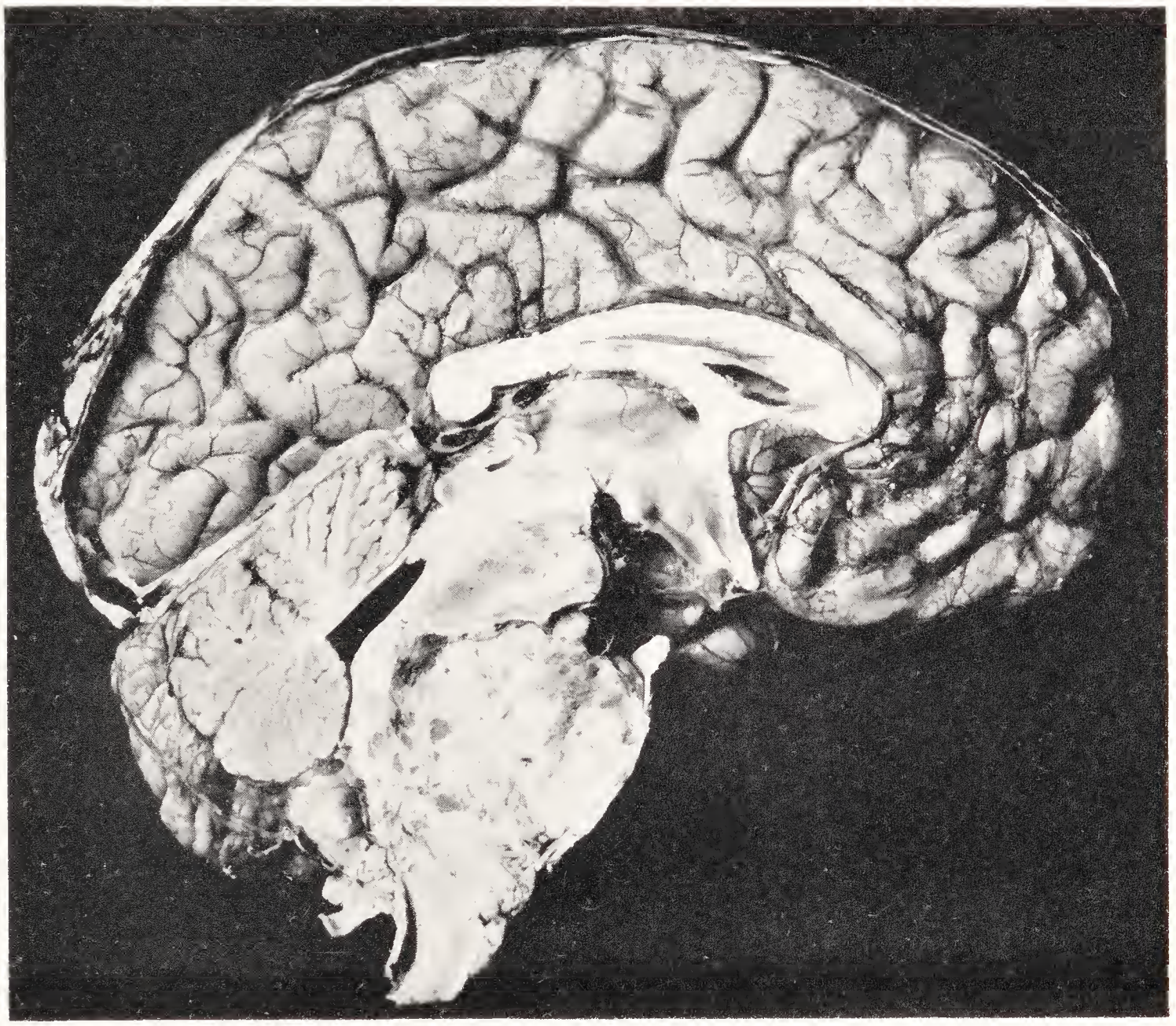

FIG. 110. Photograph of an unclassified tumour lying anterior to brain stem, mistaken elsewhere for a medulloblastoma and subjected to radiation. Death following a radiotherapeutic session. Primary epithelial tumour of obscure origin with multiple spinal metastases.

neoplasms awaiting future interpretation. The brief account of one of them, recently, the subject of discussion in our laboratory may be given as a final illustration. It exemplifies, moreover, the type of case which has come to be included in the series as "verified" without preliminary operation—at least, in our clinic. Table VI in the next section will make clear that out of the 2,023 patients comprising the entire series, only 1,870 were operated upon so that 153 of the lesions were first disclosed without preceding surgical intervention at our own hands. The story follows:

A child eight years of age while under the observation of the late Dr. Charles Locke at the Cleveland Clinic for a probable median cerebellar tumour, was operated upon as an emergency on *December 12, 1928*, because of serious symptoms following a radiotherapeutic session. A suboccipital exploration disclosed a greyish tumour-mass alongside the medulla which was supposed to have come from the IVth ventricle; a fragment was removed for study and the wound closed. A pathological diagnosis of medulloblastoma was made.

A year later the patient was admitted to the Brigham Hospital (Surgical No. 35433) *in extremis*. Because of the original diagnosis and the advanced

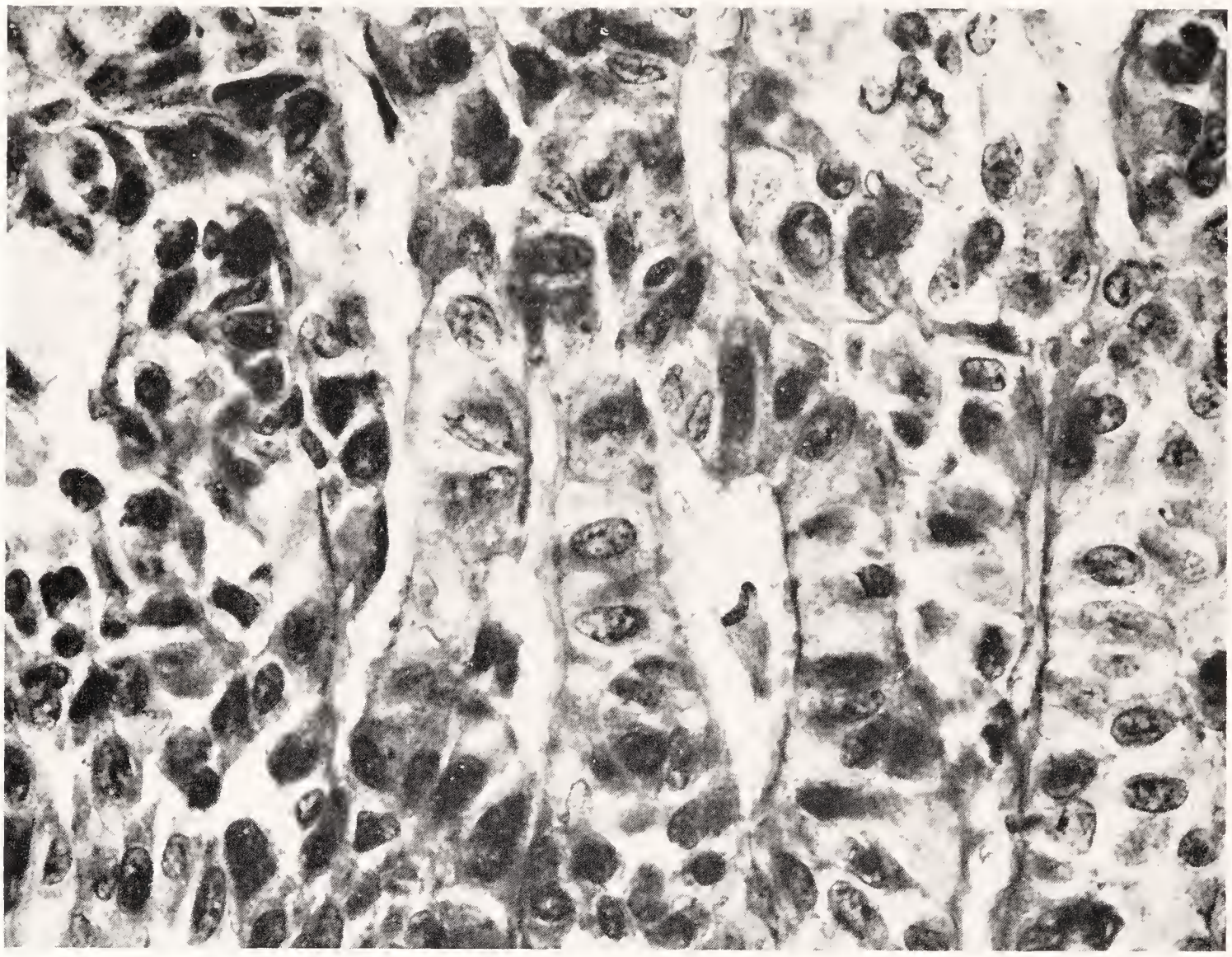

FIG. 111. Epithelial-like cells arranged in columns of tumour shown in Fig. 110 (phosphotungstic acid hematoxylin, ×600).

symptomatology, further intervention seemed unjustifiable and the child succumbed to an hyperthermia a few days after admission following radiation.

The postmortem examination showed a highly malignant tumour lying anterior to the brain stem which was greatly deformed and invaded by the growth (*cf.* Fig. 110). Multiple metastatic nodules were present throughout the spinal canal. The tumour was not only most peculiar in its position but has baffled attempts to identify its nature other than that it appears to be a highly malignant epithelial tumour of some unusual type (Fig. 111) which is certainly not a medulloblastoma.

In this assembly of 17 unclassified primary tumours of the brain, there were 23 operations with one postoperative fatality.

Statistics.—For the combined group of 44 miscellaneous tumours, 41 patients were operated upon 63 times with 5 deaths giving a case-mortality of 12.2 per cent and a 7.9 per cent operative mortality. These percentages which mean very little at the best, have been augmented during the past three years, as Table VI will show, by a single death in six cases after nine operations.

Operative Statistics in General

Unless one somehow makes a game of his daily operative tasks, they become highly irksome—and games are scarcely worth playing unless one keeps a score. In golf, for example, it is only by the score that a player can tell whether his game is improving or falling off; and only when his competitors keep score by the same standards can it be told by comparison of figures whose game is the poorer. And when it comes to match play, it's safe to have onlookers count the strokes lest one of the contestants conveniently fail to remember having lifted a ball out of an unplayable "lie." Perfectly honest and well meaning persons have been known to cheat themselves in games of solitaire, but they are less likely to do so when someone is looking over their shoulder. I therefore have left to unprejudiced persons the calculations of mortality percentages included herein. All this and more I have told in another place.[91]

Standards of computation.—In calculating the mortality percentages the standard which we have set for ourselves is that every death in hospital following an operation from any cause whatsoever, no matter how long the interval, is recorded as a postoperative fatality. There is no possibility of any exception being made to this rule, however justifiable it might appear to be, for the record is automatically made by a secretary from the completed case record after the patient's hospital discharge, living or dead. Were this precaution not taken, those personally interested would, now and then, find the temptation to evade an unnecessarily severe standard well nigh irresistible.

But should one begin to make exceptions to the rule, there would be no end to them—a patient about to be discharged after a successful operation has a perforated gastric ulcer; another gets out of bed at night to go to the toilet, trips over an obstruction and dies in a few hours from a fracture of the base of the skull; another during an epidemic of influenzal pneumonia has a fatal infection; still another has a coronary thrombosis five weeks after making a perfect recovery from his tumour extirpation. Similar examples might be multiplied and were they not automatically recorded as postoperative deaths, the temptation to exclude fatalities from other complications more obviously postoperative, such as pulmonary embolism, postoperative pneumonia, tuberculous meningitis after the successful removal of a tuberculoma, and so on, would be difficult to resist since no sharp line can be drawn between those due and those not due to the operation.

Having no convalescent home to which patients may be transferred and since a large proportion of them come from a distance, they are neces-

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[91] Intracranial tumours and the surgeon. Lancet (Lond.), 1925, ccix, 956–962.

sarily retained in hospital longer than would otherwise be necessary,* and there is ample time for intercurrent disorders to develop—e.g., a prostatic obstruction or a strangulated hernia—which bring additional risks. Another element which tends to increase the percentage of postoperative fatalities among verified tumours is the high incidence (averaging over 90 per cent) of postmortem examinations that are secured. Owing to this, many tumours are identified at autopsy which otherwise, owing to negative explorations, would have remained in the list of tumours unverified. What is more, we frequently retain in hospital for indefinite periods—five months in one instance—patients whose tumours we have failed surgically to verify with the understanding that in the end permission for an autopsy will be given. Then, too, as was stated in another connection, *the case-mortality of all malignant gliomas, in the process of working out their life history, should theoretically be 100 per cent*; for if operations for recurrences are systematically pursued to the end, it is almost a certainty that the last of them will be followed by a postoperative fatality. With all these things to consider, it is obvious that the operative statistics of two surgeons with equal skill and experience may legitimately vary within wide limits.

In all calculations of operative-mortality percentages there is still another element to consider: viz., *What is and what is not to be recorded as "an operation"?* Even though they may be attended with risk and lead to a fatality which permits postmortem verification of a tumour, we exclude, as all others would do, the simple punctures—lumbar, cisternal, transphenoidal or ventricular—which do not require an incision. Nor do we record as operations the minor surgical procedures necessary for the securing of muscle from the patient's leg, nor those for blood transfusions or those for ventriculography, even though the latter procedure may at times be hazardous and occasionally lead to a fatal issue. We do, however, record as separate operations those requiring more than one session for their completion as they are almost invariably critical performances; and for the same reason we also record emergency re-elevations of osteoplastic flaps necessitated by postoperative clot formation.

Then there is a final point to be decided: viz., *When does the operation begin?* Does it begin with the ward preparations, or with the anaesthetic, or only after an incision has been made? In many patients with brain tumours having an advanced syndrome the condition at best is serious. Sudden respiratory failure may occur should a patient with a cerebellar tumour strain to expel a preparatory enema, or have the neck unduly twisted while the scalp is being shaved, or, in days when ether anaesthesia was employed, from the early effects of the anaesthetic. Many patients after such accidents have been immediately operated upon under artificial respiration and some few of them thus saved.

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* The average hospital sojourn of the last 100 consecutive cases with surgically verified tumours has been 39 days.

No surgeon would conceivably hesitate for an instant to face emergencies of this kind though they are very bad for one's mortality percentages. In the last consecutive 50 operations for acoustic tumour, for example, one of the two recorded fatalities was that of a patient operated upon in an agonal state after a sudden respiratory failure. Had the surgeon been thinking of his score rather than of possibly saving a life, his mortality figures for this particular group of cases would have been cut in half. One must draw the line somewhere and it seems fair to do so with the incision of the scalp.

1. Mortality percentages for the series as a whole.—The writer's experience in neurosurgery may be divided into three decades: the first as a beginner at the Johns Hopkins Hospital, from 1901 to 1912; the second, with its lost ground difficult to regain, due to a two years' absence during the War; and the third, from 1922 to 1931, during which period detailed week-to-week statistical records with annual compilations of the intracranial tumours have been kept by Dr. Eisenhardt, who made a detailed report on the subject two years ago.[92] A highly condensed table (*cf.* Table IV) limited to the operative mortality percentages of the four major groups of verified tumours, as given in her paper, contrasted with the results the past three years, is appended.

TABLE IV

COMPARISON OF OPERATIVE MORTALITY PERCENTAGES FOR VERIFIED TUMOURS OF FOUR MAJOR GROUPS DIVIDED IN THREE PERIODS

	Hopkins Series to 1912 per cent	Brigham Series to 1929 per cent	July 1928 to July 1931 per cent
Gliomas (varia)	30.9	17.8	11.0
Pituitary Adenomas	13.5	5.3	5.7
Meningiomas	21.0	10.3	7.7
Acoustic Tumours	25.0	11.5	4.4

2. Mortality percentages year by year.—The preceding table shows, as would be expected, a progressive improvement in the figures that has come with the experience of later years. As a matter of fact, during each year of the last decade there has been a definite tendency to an annual lowering of the case- and operative mortality as shown in Table V. This table gives the mortality figures for the cases discharged living or dead between May 1 and May 1 of each successive year. And were the figures included for the 549 patients admitted or readmitted with tumours unverified during these years, the percentages would be still lower in view of the relatively few fatalities (2.9 per cent case-mortality and 2.5 per cent operative mortality) in the unverified group.

[92] Eisenhardt, L. The operative mortality in a series of intracranial tumors. Arch. Surg., 1929, XVIII, 1927–1935.

This table points out, what the operating members of the neurosurgical staff were themselves conscious of: namely, that in 1927 and 1928, on the introduction of electro-surgical methods, a number of patients, whose tumours when exposed had been regarded as inoperable, were called back and reoperated upon with a high mortality rate partly because of the dangerous procedures undertaken and partly because of inexperience with electro-surgical principles.

TABLE V*
ANNUAL STATISTICS OF OPERATIONS FOR VERIFIED TUMOURS INCLUDING NEW AND OLD CASES FROM 1922–1931

Successive May 1 to May 1	Number of patients	Patients operated on	Number of operations	Postoperative deaths	Case-mortality (per cent)	Operative mortality (per cent)
1922–1923	104	94	130	22	23.4	16.9
1923–1924	156	140	190	26	18.6	13.7
1924–1925	137	113	142	21	18.5	14.7
1925–1926	155	133	172	25	18.8	14.5
1926–1927	184	161	217	24	14.9	11.0
1927–1928	185	149	183	28	18.7	15.3
1928–1929	205	179	226	26	14.5	11.5
1929–1930	178	147	191	24	16.3	12.5
1930–1931	200	170	219	15	8.8	6.8
Total	1504	1286	1670	211	16.4	12.6

Apart from the figures for this particular 1927–1928 twelve-month, there has been a slowly progressive decline in the mortality percentages with a pronounced drop during the last year, which came somewhat as a surprise even though we were aware that it has been a good year. This is all the more gratifying in view of the fact that as time goes on the clinic carries an ever increasing burden of patients readmitted for recurrence of symptoms; and though reoperations for medulloblastomas and glioblastomas are perhaps less readily undertaken than formerly, even the most conservative among us can hardly refuse to reoperate upon the less malignant lesions like meningiomas, neurinomas and astrocytomas when symptoms recur.

3. Mortality percentages for the separate tumour groups.—In closing the discussion of the several tumour groups considered from a surgicopathological point of view, the mortality rate for each of them has been given with the text. These calculations, which may advantageously now be reassembled, are particularly illuminating in that they show how the percentages tumble so soon as the life history of any particular tumour

* It should be clearly understood that the computations on which the figures in Table V are based represent each year's work taken by itself, including therefore both new and old patients, with primary operations as well as those for recurrences. It is, in other words, an operative and not a histopathological tabulation such as is given in Table I, in which a verified tumour appears only once.

has been thoroughly worked out. Of only a few tumours can it be said that this has been done with sufficient thoroughness to affect the operative results, but these few furnish striking illustrations.

For example: The operative mortality of the once dreaded acoustic tumours, (as shown in Table III, page 91) has fallen for each successive 50 cases from a 28 to 20 to 14 to 4 per cent case-mortality. The present operative mortality for the chromophobe adenomas, formerly *circa* 13 per cent, has also dropped, to slightly below 4 per cent. The figures for the cerebellar astrocytomas, practically unknown ten years ago, have fallen from a 28 per cent case-mortality for the first 25 patients to 4 per cent for the last 25 cases. Even the highly malignant glioblastomas of the cerebrum have shown a drop from 24 per cent for the whole series to 14 per cent; and now that the cerebellar medulloblastomas are better understood, even these—the most disheartening of all brain tumours—may be expected to show a great improvement in their operative percentages.

In Table VI, the mortality figures have been assembled, not only for the eleven major subdivisions of the verified tumours, which have been independently discussed, but separately for the unverified tumours. The table has been divided into two sections, the first giving the operative figures for the entire series, which carries the heavy load of fatalities of the early years of inexperience. In the second section the figures are those only for the new cases that have first come under observation in the three-year period from July 1, 1928 to July 1, 1931.

This table, therefore, by the exclusion of old cases readmitted during the last three-year period because of the symptomatic recurrence of tumours imperfectly treated at an earlier day, gives a clearer idea of what results may reasonably be expected of those newcomers to neurosurgery who can profit, not only by the present-day improvements in technique, but by the existing state of our knowledge regarding the life history of the various lesions. And should they take warning from the experience of others in avoiding over-radical attempts to remove large congenital craniopharyngiomas, in refraining from operating on obviously metastatic tumours, and in refusing all secondary operations for recurrences, they could easily attain a case-mortality of 4 or 5 per cent for the whole.

Factors influencing mortality percentages.—These wholesale statistics, given in the last three tables, will serve, I hope, to give others who engage in like tasks something to play against. The more important figures are those which pertain to special tumours in special situations and they will be found in the body of the paper where the various lesions are separately considered. Had it not been for the industry of Dr. Eisenhardt with some others working under her direction whose names I have mentioned, these calculations would never have been made; but now that they have been, they may well enough be made public even though there is no reason for taking pride in what they show. The high mortality percentages of the early cases still cast their shadow over the figures for the complete series.

TABLE VI
COMPARISON OF MORTALITY PERCENTAGES FOR COMPLETE SERIES AND PAST THREE YEARS

Verified tumours	Entire series (30 years) 1901–1931						New cases (3 years) 1928–1931				
	No. pts.	Pts. op. on	No. ops.	P.o. deaths	Case-mort. per cent	Op. mort. per cent	No. pts.	No. ops.	P.o. deaths	Case-mort. per cent	Op. mort. per cent
I. Gliomas (varia)	562	780	1,173	202	25.9	17.2	198	282	31	15.7	11.0
II. Pituitary adenomas	360	349	403	25	7.1	6.2	59	70	4	6.8	5.7
III. Meningiomas	271	260	489	54	20.8	11.0	69	103	8	11.6	7.7
IV. Acoustic tumours	176	171	219	25	14.6	11.4	41	45	2	4.9	4.4
V. Congenital tumours (varia)	113	106	160	23	21.7	14.4	17	25	4	23.5	16.0
VI. Metastatic and invasive	85	63	80	18	28.6	22.5	10	11	4	40.0	36.4
VII. Tuberculomas and syphilomas	45	40	49	15	37.5	30.6	4	5	0	0.0	0.0
VIII. Blood-vessel tumours	41	37	59	6	16.2	10.2	7	10	1	14.3	10.0
IX. Sarcomas (primary)	14	12	17	6	50.0	35.3	0	0	0	—	—
X. Papillomas	12	11	23	3	27.3	13.4	1	2	0	0.0	0.0
XI. Miscellaneous	44	41	63	5	12.2	7.9	6	9	1	16.6	11.1
Total	2,023	1,870	2,735	382	20.4	13.9	412	562	55	13.3	9.8
Unverified tumours	859	496	557	12	2.4	2.2	66	73	0	0.0	0.0
Grand total	2,882	2,366	3,292	394	16.6	11.9	478	635	55	11.5	8.7

It has been erroneously assumed in some quarters that the improved results of recent years are due to earlier diagnoses rather than to greater skill and experience—in other words, that the neurosurgeon of to-day deals with a selective list of relatively favourable lesions. This assumption is far from the actual facts. In reality, each year problems become more difficult than those of the year before. The proportion of patients admitted as "forlorn hopes" in the terminal stages of their malady, often after ill-judged procedures at the hands of surgeons with little or no neurosurgical training, is as large as it ever was. What is more, each succeeding year sees tumours surgically exposed, like tumours of the third ventricle, which formerly were regarded as hopelessly inaccessible. Hence, all things considered and in spite of the constant improvement in diagnosis and surgical technique, the operations as time passes become increasingly critical and difficult.

The principal steps which have made it possible not only to attack the more formidable problems of the present day but at the same time to lower the operative mortality may be chronologically enumerated: (1) The generally accepted methods of decompression to relieve tension; (2) Such irreproachable wound healing that secondary infections are practically unknown; (3) The separate closure of the galea by buried, fine-black-silk sutures which has made the once dreaded fungus cerebri nigh forgotten; (4) In place of ether inhalation, the introduction by de Martel of local anaesthesia now supplemented when necessary by the rectal administration of tribromethanol; (5) The more precise tumour localisation which in obscure cases Dandy's ventriculography permits us to make; (6) The use of a motor-driven suction apparatus as an indispensable adjunct to every operation; and (7) The successive improvements in methods of haemostasis which since 1927 have been most advantageously supplemented by the introduction of electro-surgical devices.[93,94]

But the operation itself is by no means the whole story. The after care is equally important for unsuspected complications may arise at any moment which if overlooked or neglected may wholly turn the scale. This has been well summarized in Dr. Eisenhardt's paper[92] of two years ago:

> Rarely is more than one major operation for tumour scheduled for one day. Most of the operations are carried through under local anaesthesia, and all are started in this way. Patients who have been subjected to a craniotomy are not moved from the operating suite until the danger of the formation of a post-operative extradural clot has passed. After critical cerebellar operations, particularly if inhalation narcosis has been necessitated, the patients are usually left on the table for several hours until they have fully recovered, and they are often kept in the operating suite for a number of days. Those with deglutitory difficulties must often be fed through the nares for prolonged periods. For charity patients who are in a critical condition, from this or some other cause, special nurses are provided and paid for out of a fund donated for the purpose.

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[93] Cushing, H. Electro-surgery as an aid to the removal of intracranial tumors. Surg., Gynec. & Obst., 1928, XLVII, 751–784.

[94] McLean, A. J. The Bovie electro-surgical current generator. Some underlying principles and results. Arch. Surg., 1929, XVIII, 1863–1873.

Since this was written we have taken an additional safeguard: namely, in providing for the undivided service of a highly trained nurse, who, while the surgeons are engaged in their time-consuming operations, can devote her attention to the more critically ill of the thirty or forty patients either awaiting operation or already operated upon whom we sometimes have under observation at one time. Unquestionably many lives have been saved in this way, for less experienced nurses or junior house officers can hardly be expected to appreciate the significance of symptoms which indicate that something is going wrong with a patient recently operated upon for a brain tumour; and a few hours' delay due to the misinterpretation or neglect of a warning signal may mean the difference between a fatality and a recovery.

But however much the factor of postoperative care may have to do with one's mortality percentages, of chief importance is the operation itself. The many publications from the clinic during the past several years have dealt principally with the neuropathological or experimental aspects of the brain-tumour question and with few exceptions little has been said of the operative procedures themselves. These, as a matter of fact, come to be so quickly superseded by improved methods, and even when fairly well standardized, their finer points are so difficult properly to describe in words, that few surgeons take the trouble to make the attempt. Information of this sort can far better be handed on from teacher to pupil by personal contact at the operating table. And when this is supplemented by the establishment of interurban societies of neurosurgeons, such as those already successfully launched in Great Britain and America, not only are desirable friendships and sympathetic associations thus fostered, but information regarding new technical methods becomes quickly disseminated by seeing one's peers attack the surgical problems which are common to all.

This report, which is certainly the last I shall ever attempt to make on the subject of brain tumours as a whole, cannot properly be concluded without paying tribute to my successive assistants and co-workers during these past many years who have faced the brunt of the work and shared the responsibilities. Many of them have already operated successfully upon more brain tumours than I supposed existed when I was their age. And since, in Leonardo's words "It's a mediocre pupil who does not excel his master," a surgical record, far more creditable than that given herein, will certainly be attained by most of them.

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THIS BOOK

INTRACRANIAL TUMOURS

Notes Upon a Series of Two Thousand Verified Cases With Surgical-Mortality Percentages Pertaining Thereto

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